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A FRENCH STEAM BREWERY.

SEEING the constant increase that is taking place in the consumption of beer, and the great competition that exists among manufacturers of it, every invention that is capable of reducing the prime cost can be only well received by brewers. It is from this standpoint that we think it our duty to publish a description of a new system that has been invented and patented by Mr. A. Girard, of Paris.

This improved brewery, which is simple in construction, and necessitates neither masonry foundations nor brick furnaces, and occupies but little space, permits, as compared with the ordinary type, of a great saving being effected in the cost of the first establishment, as well as in fuel and manual labor. The system is adapted for the manufacture of all kinds of beer, whatever be the method of maceration (infusion or decoction) and the mode of fermentation (high or low) that are adopted. The inventor has sought to obtain these multiple advantages by operating with steam.

As shown in the accompanying plate, which represents a complete plant according to Mr. Girard's system, all the apparatus rest on the floor without any foundation. An iron frame, which is supported by cast iron columns, serves as a seat for the coppers. A light platform, that runs along the various apparatus, facilitates such manipulations as putting in hops, etc., closing the vessels, maneuvering the cocks, etc. To the extreme right of this series of apparatus is a tubular, inexplosible boiler (A), such as Mr. Girard's house has made a specialty of. Any other boiler, however, can be used just as well, although the vertical style, by reason of the small space that it requires, appears to be best adapted for breweries. The steam boiler employed in the present case is easy to run and keep in repair, is brought quickly to the requisite pressure, and requires no masonry furnace. The fireplace being in the interior, a simple jacket serves to prevent the loss of heat through radiation and thus diminishes the output of fuel.

Above this boiler there is a feed-water reservoir, B, which is supported by two brackets sealed into the wall. This reservoir receives the water derived from the condensation of steam in the double bottoms of the coppers. These double bottoms are connected with each other and the reservoir by means of pipes, J, provided with cocks.

Alongside of the generator stands the saccharifier, C—a large, vertical, boiler-iron vessel, provided with an agitator which is actuated by the motor of the establishment. In the top, which carries the driving gearing, there is a man-hole which may be hermetically closed by a lid that bears upon rubber. This vessel has a perforated false bottom. The shaft of the agitator carries inclined blades which, during their revolution, cross other blades that are inclined in an opposite direction and are fixed to the sides of the vessel. At its lower extremity the shaft carries an iron plate helix for causing the constant ascent of the malt, and especially that of the starch, which, through its density, tends to accumulate in this part.

The saccharifier is heated by means of steam that enters a double bottom, which allows it to circulate all around the cylinder. At the lower part of the latter, and over the double bottom, there is a second man-hole, closed by a screw plate, to allow of the removal of the malt and the cleaning of the interior. The apparatus is provided with a safety-valve, and a pressure-gauge whose metallic rod (without mercury) enters the vessel. Externally there is a dial-plate with figures large enough to be read from a distance. Finally, there is a glass window in the side to allow the operation that is going on within to be watched.

This saccharifier is tested and registered, at the time of its construction, to resist a pressure of 2 kilogrammes per square meter, corresponding to a temperature of 133° C. The double bottom, which receives the live steam, is, like the generator, registered at 7 kilos, corresponding to a temperature of 170° C.

To the left of the saccharifier stands a second cylindrical vessel, D, that serves for the manufacture of beer. This vessel, which is the one in which the hops are boiled with the wort, is, like the apparatus just described, provided with a thermometer, pressure-gauge, water-level, sight-hole, etc. At its side stands a similar vessel, E, called the hot water or small beer vat. The total capacity of these two vessels, D and E, is equal to that of the saccharifier. The role of the hot water vessel, E, is not limited to the heating of water for steeping, but has a still more important object.

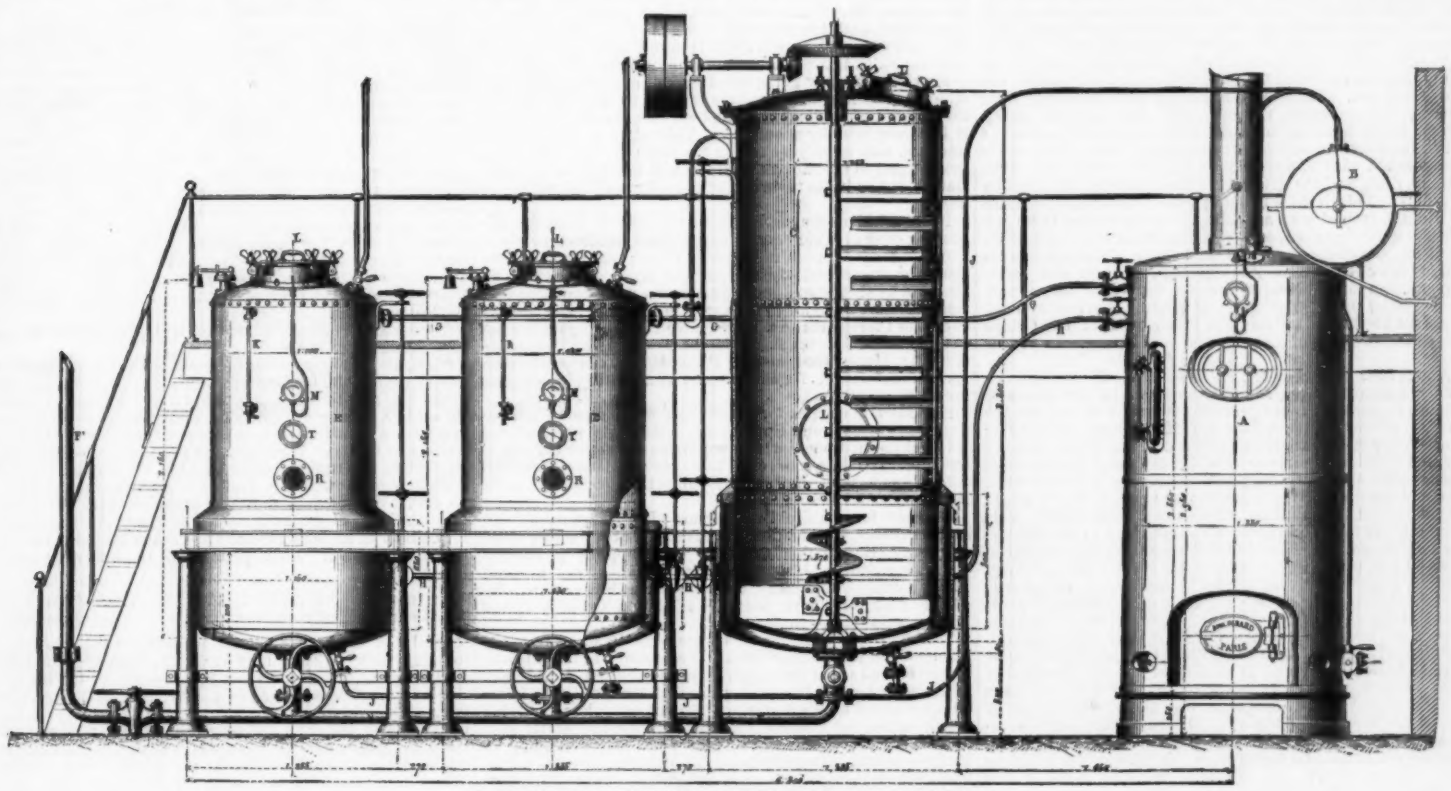
In fact, by the aid of blow-off cocks in the bottoms, and through the pressure exerted by the steam when the upper cocks of the vessels are opened, the contents of the various apparatus can be transferred from one to the other respectively. It follows that after the malt has been moistened from the hot water vat, the latter may serve to boil and hop small beer, while the stout beer is boiling in the first copper. In this way the two qualities of beer that usually result from all brewings may be obtained very economically.

The apparatus under consideration permits, as we have said, of the use of all modes of brewing, and of performing the operations with the greatest cleanness. Nothing is easier than to gradually reach the requisite temperature through steam heating. The thermometer is merely consulted, and, according to its indications, the opening of the heating cock is regulated. In order to obtain a sweet beer that contains much dextrine and little alcohol, the heating is arrested at 65°; if the beverage is to contain much alcohol, the heat is carried to 70°; and, if a very alcoholic, light, and digestible beer be desired, the heat is carried to 80°.

As regards facility of manipulation, it is well to remark that the difficult and delicate operation of maceration in brewing by infusion is here much simplified. The transparent glass in the side of the mash-tun or saccharifier permits, in fact, of all the transformations of the mash being watched, and the thermometer gives the most accurate indications as to the temperature of the interior. Owing to these means of control, it is easy to avoid, during the progress of the work, irregularities that might interfere with the saccharification, reduce the yield of malt, interfere with the perfect clarification of the wort and beer, and alter the delicious aroma of the malt sugar.

The operations once finished, the steam and boiling water that are always present in sufficient quantity allow the vessels and pipes to be readily cleaned. It requires but one man to perform these different maneuvers, and to attend to all the operations. Finally, it is of interest to add that, by means of these apparatus, two brewings per day may be effected.

Description of the Plate.—A. Steam generator. B. Feed-water reservoir. C. Mash-tun. D. Hop copper. E. Hot water or small-beer copper. F. Pipe that connects the coppers. G. Pressure pipe for transferring and elevating the products. H. Steam pipe connecting the double bottoms. J. Pipe that leads the condensed steam to B. K. Level of the liquids. L. Man-holes. M. Pressure gauge. T. Thermometer. R. Sight holes.—*Revue Industrielle.*



FRENCH STEAM BREWING PLANT.

THE IRIDIUM INDUSTRY.*

By WM. L. DUDLEY, Cincinnati, O.

IT is my desire to call attention to a new industry which was started about four years ago, through the discovery by Mr. John Holland, a resident of this city, of methods suitable for working the metal iridium. This metal has been known since the year 1803, having been discovered by Smithson Tennant while investigating the metallic residue which remained when planitum ores were dissolved in aqua regia. The metal is classed among the rare metals, as it is not found in large quantities, although it is quite widely distributed geographically. It is found in California, Oregon, Russia, East India, Borneo, South America, Canada, Australia, and in certain parts of France, Germany, and Spain. The principal sources of supply of the metal are Russia and California; it is nearly always found with either platinum or gold, is extracted from those ores as a by-product, and is always found in small grains or fine powder, the largest pieces being about the size of a grain of rice. In nature it is generally alloyed with other metals, and the two metals with which it is most commonly alloyed are platinum and osmium; the platinum alloy is called platin-iridium, and the osmium alloy osmiridium or iridosmine. The grains of platin-iridium are sometimes found as small cubes with rounded edges, while the iridosmine usually exists in the form of flat irregular grains and occasionally as hexagonal prisms. The supply of metal which is derived from Russia is generally obtained from the platinum mines which are situated in the Ural Mountains; while in California it is found principally in placer gold-washings. The ores of iridium are a source of great annoyance when mixed with gold-dust on account of its specific gravity, which is about 19·3, being nearly the same as that of gold. Consequently, it is impossible to separate the gold from the iridium by the process of washing; the separation may, however, be made either by the amalgamation of the gold (as neither iridium nor its ores combine with mercury), or by dissolving out the gold in aqua regia.

In the mints these metals are frequently separated by melting the gold-dust and allowing the molten mass to remain in the crucible for some time, during which the iridium slowly settles to the bottom, as it does not alloy with the gold under such circumstances. The gold is then poured off from

* Read at the Cincinnati meeting, American Institute of Mining Engineers, Feb., 1884.

the top, and the dregs in the bottom of the crucible are found to contain the greater quantity of the iridium. The gold contained in the dregs is then dissolved, and the iridium is found in the residue.

In Russia it is contrary to the law to possess or deal in iridium ore, and consequently the government takes possession of all the ore which is mined or extracted from the platinum ores in that country, and it is stored in the vaults of the Royal Mint. The reason for the law is, that some years ago the Russian government found that speculators in gold-dust would sometimes add iridium to it (which often escaped detection by the officials of the mint), for the purpose of increasing its weight. On attempting to work this gold they found the fine particles of iridium distributed through the ingots; on rolling the ingots into sheets, these individual grains or particles produced indentations in their steel rolls; and in striking out the coins the dies were marred and defaced, thus causing considerable loss to the government. In order to prevent this species of fraud, the government passed a law prohibiting persons from handling the metal in any way, and compelling its immediate surrender.

For a number of years experimenters have endeavored to melt the iridosmine or iridium, in order to utilize it in the arts for such purposes as could with advantage employ a metal of its wonderful properties; but until lately success has been only partial.

I may here briefly describe the properties of the metal itself. Iridium possesses a white luster, resembling that of steel; its hardness is about equal to that of the ruby; in the cold it is quite brittle, but at a white heat it is somewhat malleable It is one of the heaviest of metals, having a specific gravity of 22·38. When heated in the air to a red heat the metal is very slowly oxidized; but upon raising the temperature to about 1,000° C., it parts with its oxygen, and hence at a high heat (above 1,000° C.) it is not oxidized. It is insoluble in all single acids, but is very slightly soluble in aqua regia after being heated in the state of fine powder for many hours. In a massive state, however, aqua regia does not attack it.

In attempting to fuse iridium heretofore, it has been found by experimenters that the best results that could be obtained were by means of the oxyhydrogen or electric furnace, but that with either of these means of fusion they could only work a very small quantity of the metal at a time, and obtain a globule of very small size. Previous to the present time iridium has had substantially but one use (with the exception of alloying with platinum), viz., for pointing gold pens. The iridium point is commonly called "diamond point" upon a gold pen, and it consists simply of a small grain of iridosmine which has been selected for the purpose, and soldered to the tip of the pen. These are selected by first removing from the ore, with a magnet, the magnetic oxide of iron which always accompanies it, and then dissolving out, by means of acids, the other impurities which may be present; the ore is then washed with water, dried and sifted in order to remove the fine dust, and the sifted ore is then ready for the selection of points. This is done by an operator, who rolls the grains of iridium around with a needle point, examining them under a magnifying glass, and selecting those which are solid, compact, and of the proper size and shape. These points are usually selected in three grades, small, medium, and large, depending upon the size of the pen for which they are intended to be used. The grain of iridium having been soldered on to the end of the pen, it is sawed in two (which makes the two nibs of the pen), and ground up to the proper shape.

About four years ago Mr. John Holland, the well known gold pen manufacturer, found it necessary to have pieces of iridium larger than those generally found in nature for the purpose of making points for the Mackinnon stylographic pen. After many experiments he found that by heating the ore in a Hessian crucible to a white heat and adding to it phosphorus, and continuing the heating for a few minutes, he could obtain a perfect fusion of the metal, which could be poured out and cast into almost any desired shape. This material was found on physical examination to be about as hard as the natural grains of iridium; and in fact seemed to have all the properties of the metal itself. On chemical analysis it was found that the metal fused with phosphorus contained, according to two determinations, 7·52 per cent. and 7·74 per cent. of phosphorus. At this stage of the discovery we became acquainted with it, and began experiments with the intention of putting the product to some practical use in the arts. It was found that the presence of phosphorus rendered the metal quite readily fusible at a white heat, but this, of course, was an obstacle in the way of its use for electrical purposes. Desiring, therefore, to remove the phosphorus, we found by experimenting that by heating the metal in a bed of lime the phosphorus could be completely removed. In this operation, the metal is first heated in an ordinary furnace to a white heat, and finally, after no more phosphorus makes its appearance, it is removed and placed in an electric furnace with a lime crucible, and there heated until the last traces of phosphorus are removed; the metal which then remains will resist as much heat without fusion as the native metal.

In mechanical applications, where the metal is not subject to great heat, it is melted with phosphorus and cast into the shape desired, and then ground or worked as the application may require. The first application to which it was put was for the manufacture of the Mackinnon pen-points. For this purpose, the metal, after being fused, is removed from the furnace and poured between two slabs of iron, which are kept apart the desired distance so as to make a sheet of iridium of the thickness required. The metal is poured, as I have said, between these plates, and the plates are brought suddenly together, on the plan of a closed ingot with a hinge, so that as the metal cools it is subjected to pressure, which closes the pores and makes a very compact casting. The slabs for the Mackinnon pen-points are about one thirty-second of an inch in thickness, and are broken up into small irregular pieces, which are soldered on a strip of brass and ground down to a flat surface by means of a copper-lap. The copper-lap consists of a plate of copper, about one-half inch in thickness and eight inches in diameter, fixed on a spindle which is made to revolve from eight hundred to a thousand revolutions per minute; the copper of which the lap is composed is wrought copper, well annealed, and consequently very soft. In order to grind with it, corundum or diamond dust is mixed with oil and applied to the flat surface of the lap by means of a flat steel instrument, upon which pressure is applied in order to force the corundum or diamond dust into the copper, thereby making a cutting surface. The iridium to be ground is held against this sharp surface of the lap, and the corundum or diamond dust gradually cuts the metal away. As the cutting material wears from the copper-lap, another application of the corundum and diamond dust is made by means of the steel instrument described; this operation is continued until the grinding is complete. After the slabs are ground to a surface they are then drilled. In the drilling operation, the iridium is first countersunk by means of a diamond drill, consisting of an upright spindle suitably fixed in a frame so as to revolve freely; the bottom of the spindle holds a small rod of brass, to the lower end of which is set a white diamond-splint. This drill is made to revolve about nine hundred revolutions per minute. The iridium is held up against the diamond with a light pressure, and the diamond gradually makes a conical hole or countersink. After countersinking the iridium, it is finally pierced by means of a copper drill, which consists of a piece of soft copper wire, which is filed down to a point and set in a drill similar to that in which the diamond is placed, but this drill makes about thirty-five hundred revolutions per minute. Corundum or diamond dust and oil is put into the countersink opening in the iridium, and then it is held up against the piece of revolving copper. The diamond dust or corundum, embedding itself in the copper, acts as a cutting surface, and finally accomplishes the drilling of the hole. The holes having been drilled in the pieces of iridium which were soldered to the brass, the brass is finally dissolved from the iridium by means of nitric acid; and then we have irregular-shaped pieces of iridium, pierced with holes. These pieces of iridium are then soldered in proper position to the end of the Mackinnon pen, fitting into the opening of which there is a valve consisting of an iridium-pointed wire. The iridium is then ground to the proper shape on the outside by means of a copper-lap, consisting of three or more copper cylinders on a common spindle, making about three thousand revolutions per minute.

The operation of sawing iridium is carried on by means of a copper disk from four to eight inches in diameter, made of soft thin sheet copper, held between two clamps, placed on a spindle revolving at the rate of about twenty-five hundred revolutions per minute. This sheet of copper revolves in a box which contains corundum or diamond dust and cotton-seed oil. The cotton-seed oil with the cutting material adheres to the periphery of the saw, and as the saw comes in contact with a piece of iridium it gradually does the work. Cotton seed oil is preferred for this purpose to any other oil, on account of its viscosity.

I may mention briefly some of the uses to which iridium has been applied. First, I will refer to the draw-plate for drawing wire. There are at present, besides the iridium draw-plate, the ordinary steel-plate which is used for drawing heavy wire, and the ruby plate, which is used in drawing gold and silver wires, where it is desirable to have them of uniform thickness. The iridium plate is made somewhat similar to the ruby plate, consisting of a piece of iridium which has been countersunk and drilled in the usual way to the size of the hole required, and set in a brass plate, where it is firmly held by a bushing. This plate is now coming into use, and is rapidly taking the place of the ruby plate, being equal to the ruby in hardness and much more durable, since it is less liable to break or chip by rough handling or heating.

Iridium knives are made for fine scales and balances, the bearing edge of which consists of iridium, soldered firmly to a brass body. These are rapidly taking the place of the agate for fine chemical balances, and there seems to be no reason why they should not have even a more extended use, since they are superior to the agate in that they take a finer edge and thereby make a more delicate balance, and are not so liable to crack or break. They are now being used altogether by Mr. Henry Troemner, of Philadelphia, the well-known scale manufacturer, for the purpose of adjusting his weights for all of his scales.

Hypodermic needles for physicians' and surgeons' use are now made of gold and tipped with iridium, in place of the old steel pointed ones, which are liable to rust or corrode if not properly taken care of. The iridium being hard will take a good edge, and is not subject to corrosion, as is steel.

Styluses for manifold writing are also being made with iridium points, having decided advantages over either steel or agate. Iridium points are also being applied to surveyors' and engineers' instruments, and in all places, in fact, where hardness, durability, and non-corrosibility are required. For all the above uses the iridium alloyed by fusion with phosphorus is employed.

Some years ago experiments were made in order to apply this metal to the electric light. We found that an iridium electrode used upon the negative of an arc-light would keep its shape and resist the heat, provided the positive carbon which was used with it was not allowed to strike or fall too heavily upon the iridium negative. Since the metal at a white heat becomes malleable, a continual pounding or striking would gradually beat the negative out of shape. The iridium negatives are made by setting a piece of dephosphorized iridium in the end of a brass rod about six inches long and nine-sixteenths of an inch in diameter. The length of the iridium is about half an inch, ground conical in shape. It was found that the brass, being only half an inch from the arc, would resist the action of the heat; but in some cases where the lamp flamed the brass was liable to undergo partial fusion; and in such cases it was found desirable to put a thimble or cap of platinum over the end of the brass and just below the iridium, the platinum thimble being about half an inch long.

One of the most important applications of iridium which has yet been made is to the electrical contact-points of telegraphic apparatus. These contact-points consist of pieces of copper wire tipped with iridium, which are set in the instrument just as platinum points are set. These contacts will outlive many platinum contacts; are not subject to oxidization or sticking, as are the platinum ones; and all that is necessary in order to clean them when they become dirty is to pass over their surface an emery file or a piece of fine emery-paper. These contacts have been thoroughly tested by various eminent electricians and also by long continued use, and the advantages herein stated have been in every case fully demonstrated.

In the past three years we have been experimenting on methods of plating with iridium, and about one year ago we succeeded in obtaining a bright reguline deposit of iridium on base metals. This deposit resembles the natural metal, being quite hard and resisting the action of acids. There were many difficulties encountered in accomplishing this result, on account of the power of the metal to resist the action of the solvents; but we have succeeded in obtaining a solution which gradually attacks an anode of iridium, and it is hoped in a short time that all the minor practical difficulties will be overcome in the plating of articles on a commercial scale. So far we have been thoroughly testing our results, and do not feel prepared to place our work before the public until it is perfect in all its details.

For the anode in electro-plating we use iridium which has been fused with phosphorus. It contains 5 per cent. of phosphorus, which does no damage. Of course, in working out a problem of this nature, it takes several years to ascertain all the causes of disturbance; but we have not yet attributed any trouble to the phosphorus in the solution. We have made many experiments with alloys of iridium, but have practically failed to get an anode of them which would readily dissolve; but we find that the anode of fused iridium gradually dissolves, and yet not fast enough to keep the solution replenished, without the addition, now and then, of some of the pure salt, the amount depending upon the kind of solution employed. The same thing is necessary in silver and in nickel plating. Theoretically, the anode should dissolve and keep the solution up to the proper strength. In practice, that is never the case.

The solution is made by dissolving the iridium first with chlorine and sodium chloride. The iridium or iridosmine is mixed with common salt, placed in a tube, and heated to redness. Chlorine gas is then allowed to flow slowly through the tube for several hours, at the end of which time most of the iridium will have combined with the salt and chlorine to form the double chloride of iridium and sodium, which rapidly dissolves in water. From this solution we can obtain any salt of iridium which we desire. In plating with the metal, we find that a solution, very slightly acidified with sulphuric acids, gives the best results practically, although neutral or alkaline solutions work very well.

Ordinary silver solder is used in soldering iridium to other metals. Soft solder will solder the metal as well, but we seldom use it, since it is not as durable.

As to the supply of the metal, we find it, like a good many other metals, widely distributed—in Canada, and many parts of the United States, in France, and a great many European countries, and, as I have said, the largest supply has heretofore been in Russia.

There are some parties in Hamburg who deal in the ore, and we get most of it from them. We get from three to four hundred ounces annually from the United States government. We do not get more, for the reason that the mints will not knowingly buy gold-dust which contains any iridium. They examine the dust very carefully, but, in spite of their care, they get a little.

PHOTOS IN INK.

By SAMUEL C. RILEY.

IN using the velvet roller no particular precautions are needed, but the roller should carry enough ink of moderate thickness, consisting of pure olive oil and litho. transfer ink thoroughly incorporated. The greatest advantages accrue from first rolling the collotype plate with the velvet roller, covering the whole plate with a thin uniform coating, and immediately rolling the plate with a leather roller sparingly covered with the same ink as used on the velvet roller. Any amount of brilliancy can thus be obtained (provided the negative is perfect), always remembering that a little sharp rolling clears the whites effectively. I have repeatedly seen collotype plates that could not be inked up with the leather roller by itself (owing to the plates being dried badly), which gave perfect impressions after having been inked lightly all over with the velvet roller, the plate being cleared with a few gentle rolls with the leather roller.

To make a collotype plate that will give perfect impressions, proceed as follows:

First, the substratum for the plate. Take 1 ounce of ordinary dinner ale, 6 or 8 drops of silicate of soda, and well shake into a froth in a bottle, stand it by for twenty minutes, then filter. Take a clean glass plate (patent plate is best), and with a camel's hair brush go over one side of the plate; set on end to dry. When dry, go over the plate again, letting it dry this time the other way up. When again dry, let a gentle stream run on it for thirty seconds, then again dry on end. When again dry, you may coat with the following solution: 44 grains Nelson's ordinary gelatine soaked for quarter of an hour in cold water, then heated in the oven till all is melted. Then pour into it the following hot solution:

Water	½ ounce.
Bichromate of ammonium	6 grains.

Well mix and filter. On no account let the solution get to boiling point. Take an 8 by 5 plate with the dried substratum on it, and flow over it ½ an ounce of the hot gelatine solution; place at once on the leveled glass in the drying box. It should dry in two hours, and is ready for instant use. Expose under an ordinary negative for an hour, then wash in cold water for 1½ hours, and dry in the open air, which takes from 4 to 6 hours, according to the weather. When dry, damp with very weak glycerine and water, allow the moisture to slightly evaporate, roll as above mentioned, and take impression off at once.

The drying box is as under: 20 inches high, 12 inches square, the leveling glass about 6 inches from the top of the box, three sheets of loose blotting paper lying on it for the plate to rest on, a piece of iron (say) 6 by 4 by 3 heated in the fire, and placed 6 inches under the leveling glass. There should be at least three or four holes at the bottom sides of the box, and three at the top, to promote a good draught. The heat in the box should be about 120° F.—*Photo. News.*

HOW TO MAKE PHOTO PRINTING BLOCKS.

THE Pretsch method, described by Mr. Ryley and given in the *Photo. News*, is as follows: The nitrate of silver need not be added, and by "fine glue" must be understood such a gelatine as that of Coignet. Mr. Ryley says:

1. I dissolve 1 ounce of fine glue in 8 ounces of distilled water, and to 1 ounce of this solution I add 30 grains of nitrate of silver, previously dissolved in ½ ounce of distilled water; to the other 2 ounces of glue solution I add 2 ounces of a saturated solution of bichromate of potass, and while warm I add to it the nitrate of silver and mix well.

2. I level a glass plate, and pour over it as much of the above solution as will when quite dry form a film about the thickness of thin writing paper.

3. I now expose the plate to sunlight under a glass positive for about three hours, or until all the details of the picture appear when viewed by transmitted light.

4. I then wash it under water until those parts of the picture which are the least acted on by light become granulated, which is caused by a peculiar contraction of the film; the superfluous moisture must then be removed by blotting-paper.

5. You may use a negative instead of a positive, but your exposure must not be more than half the time, and you will still have a positive result and the grains of your film will be much finer. And now let me remark that in this granulation lies the whole secret of the process; and yet, strange to say, not one word can you find respecting it in the specification,

and therefore I contend that all patent right is justly forfeited.

6. A mould in gutta-percha is then taken from the film and rendered conductive by plumbago or other means, and put into the electrotype apparatus until you have a deposit of copper of sufficient thickness to form a matrix, from which you can deposit a thick copper plate strong enough to print from.

The progress and condition of engineering works have often been recorded by the camera; indeed, we may mention that twenty-nine years ago the great railway bridge across the Dnieper at Kiew was being constructed by Mr. C. Vignoles. Each day a photograph was taken and forwarded to the Czar.

Our correspondent has, however, struck out a new path in photography! and although we quite sympathize with him as regards his years of fear lest the bridge should have tumbled about the ears of himself or family, we see no particular advantage in placing the condition of the once-existing bridge on record in our paper, except as an instructive illustration of a field of usefulness for photography.

His idea of writing a letter of complaint to a newspaper, and sending a typographic photograph or printing block illustrating his views, is an excellent one, and it seems to us that the police authorities might well take the hint. What, indeed, could more effectually assist in the discovery of criminals who are "wanted" than a publication of phototypic portraits in the *Police Gazette?* Col. Dillon, the successor of Mr. Howard Vincent, will doubtless consider the matter.

ELECTRO-MAGNETIC ORE DRESSING.

A FEW years since, the announcement was made through the technical press that a system of electro-magnetic ore dressing had been tried in Germany. The plant which has

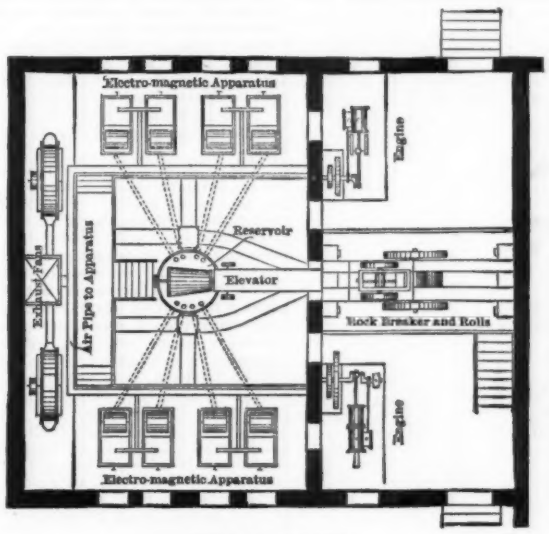


FIG. 1.—PLAN.

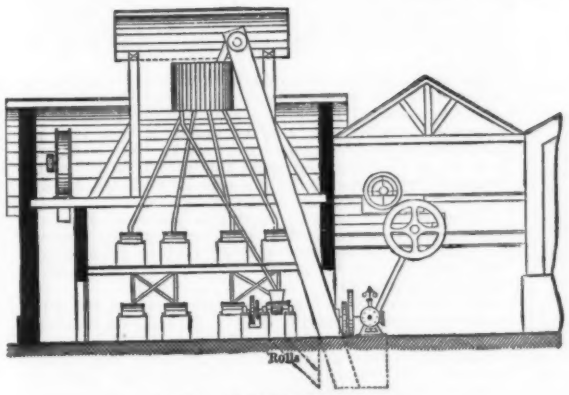


FIG. 2.—ELEVATION.

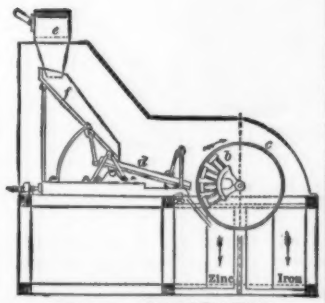


FIG. 3.—SEPARATOR.

now been at work for three years at the Friedrichssegen mine, near Oberlahnstein, has been recently described in greater detail by Herr Otto Heberle, at a meeting of the Verein Deutscher Ingenieure. The Friedrichssegen mine produces ore containing a good deal of iron ore and zinc blende, which are difficult to separate, because their density is nearly the same. Two classes of ore are mined, cobbing ore, from which some pure salable ore is separated by hand sorting, and smalls. That part of the cobbing ore that is rejected in sorting goes to the electro-magnetic separators, while the smalls are dressed in the usual manner. Middlings containing blende and iron ore are obtained also in this dressing, and they too go to the electro-magnetic plant. The material for that process obtained by sorting ranges in size from 40 to 120 millimeters, while the ore from the ordinary dressing plant is 6-millimeter stuff. It is worked by first roasting, separating by means of the electro-magnets, and then jigging.

The object of the roasting is to prepare the material for the subsequent process by converting the iron into magnetic oxide. The picked lump ore is roasted in a shaft kiln, with coke dust as fuel. The consumption of fuel is slight on account of the sulphur in the blende, not being greater than 110 pounds to 8 tons of ore, which are daily put through one furnace. The furnace requires the labor of two men. The roasted ore goes to a rock breaker and to a pair of rolls below it, which reduce the rock to a 5-millimeter grain, and deliver it to an elevator that takes it to the electro-magnets.

The fine middlings obtained in the wet dressing are worked in one reverberatory furnace with a hearth 12 feet wide and 38 feet long, provided at each side with a fireplace, 5 working doors, and a discharge opening, and in one smaller reverberatory, the hearth of which is 6 feet wide and 22 feet long, and which is provided with one fireplace, two working doors, and a discharge opening. Roasting takes an hour and a half. These two furnaces have a capacity of from 18 to 20 tons in twenty-four hours; but of course the cost of fuel and labor is much greater, being fully three times as large as that of roasting the lump in kilns. After being roasted, the ore is spread out on a cooling floor, is then passed over screens to get out sintered lumps, and is then delivered by a bucket elevator to the hopper into which the crushed and calcined lump ore goes. In this hopper, the ores are put through a screen with 4-millimeter mesh, the fines falling through chutes to the magnetic separators, while the coarse is crushed by a small set of rolls.

The dressing is done by 16 electro-magnetic apparatus arranged in sets of four in pairs above one another. The upper pair receives the ore from the chutes, and partially separates the blende from the iron. The products obtained are worked over once more in the lower apparatus. They are:

1. A mixture of blende and quartz.
2. Iron ore.
3. Blende middlings.
4. Iron ore middlings. The middlings are treated over again.

As there is a good deal of dust in working, all the apparatus are connected with an exhaust fan. The apparatus, which is shown in Fig. 3, is constructed as follows:

The electro-magnets, *b*, are attached to a solid stationary shaft. In front of the brass cylinder, *c*, which revolves around the magnets, is a shaking table, *d*, and a distributer, *f*. The ore drops from the chutes and through the funnel, *e*, upon the distributer and the shaking table, which delivers it on to the brass cylinder, *c*. As soon as the ore reaches the vicinity of the cylinder, the particles of magnetic oxide are retained, while the blende drops by. By the rotation of the cylinder in the direction indicated by the arrow, the particles of iron finally escape beyond the action of the electro-magnets and fall off at the other side of the cylinder. By adjusting the distance of the shaking table from the cylinder, different sizes of ore may be treated. The electric current is generated by dynamos, one machine that requires a motive power of one horse power being sufficient to supply four separators.

With two sets of four apparatus of the plant now at the Friedrichssegen mine, 24 metric tons of ore, running from 12 to 15 per cent. of zinc, and from 20 to 22 per cent. of iron, can be treated for each set in twelve hours, yielding a product of 7 tons of blende and 18 tons of iron ore. The former contains about 33 per cent. of zinc, and the latter from 36 to 38 per cent. of iron and 10 per cent. of manganese. The iron ore is sold as such. The zinc ore is worked further by screening to obtain 1, 2, and 3-millimeter sizes and jigging. The object is to get rid of the gangue in the product, and to obtain the lead in it. In this manner, the percentage of zinc in the ore is carried up to 38 per cent., while the lead ore carries about 65 per cent. of lead, and 0·004 per cent. of silver. The fine dust is washed in buddles, yielding lead beadings carrying 55 per cent. of lead, and zinc beadings containing 32 per cent.

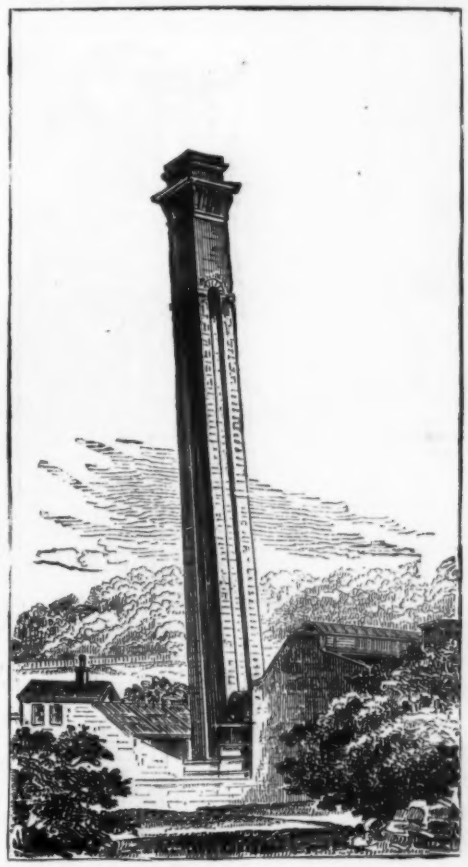
CHIMNEY CLIMBING.

AT the beginning of last year Mr. Richard Anderson purchased the goodwill and business of Messrs. Sanderson and Co., electrical engineers, lightning conductor manufacturers and exporters, of 44 Essex Street, Strand, London, W.C.; and Faraday Works, Huddersfield, and we are favored by him with the following communication. He observes that some practice and skill were required for the attainment of distinction in the art of kite-flying for getting at the top of tall chimneys. Mr. Solomon Sanderson, of Huddersfield, had some years ago acquired a high reputation for his successful practice of this craft. As recently as nine years ago it was no uncommon thing to come across him practicing with his kites at Melton Moor, five miles from Huddersfield, where he seems also to have had great delight in repeating Franklin's renowned experiment of gettings sparks from the string of a kite when highly charged storm clouds were hovering above. But the tall chimney engineering owes a larger debt to this ingenious constructor, who died about three years ago, after having spent a long life in useful and successful work. He contrived the means which have now practically superseded the use of the kite, and which it is one object of this little sketch to bring under review.

Mr. Sanderson's method consists of pushing length after length of short segments of a ladder, as it were telescopically, up against the perpendicular face of the shaft of the chimney, and of climbing simultaneously upon the lengthening-out ladder as it goes—a most formidable looking proceeding, it will be allowed, when it is a chimney of 250 or 300 feet that is so attacked, but one which has, nevertheless, been so perfected by the sagacity of the inventor and his successors, that it is now employed, in the hands of good climbers, with an almost complete immunity from dangerous risk.

The first step in the erection of the ladder consists in placing one of the sections standing perpendicularly upon the ground against the bottom of the chimney. A workman then drives an iron dog or hold-fast firmly under the brickwork one foot up from the bottom of the ladder, and one foot down from its top. These hold-fasts are of a hooked form, so that they can each be made to clamp one of the rungs of the ladder when they are driven home upon it into the brickwork. The segment of the ladder is as firmly attached to the shaft of the chimney, when this has been accomplished, as it would have been if it were originally an essential part of the structure.

The essential points in this ingenious process which furnish a ready explanation of its success thus are: (1) The temporary lashing of each section of the ladder when it is half way up, so that the climber can get safely to the top, as it is held still attached to the pulley, and fix a fresh block above its upper extremity for the accomplishment of the second half of the hoist; (2) the joining of the sections by appropriate sockets as each one is placed in position upon the one beneath; and (3) the fixing of each section, when it is once lifted into its place, by the hold-fasts driven into the brickwork of the chimney. The latter virtually creeps up to the top of the chimney, joint above joint, and fixes its tenacious fangs into the brickwork as it goes. The process is so easily performed by practiced hands that the highest chimneys are scaled in incredibly brief intervals of time.

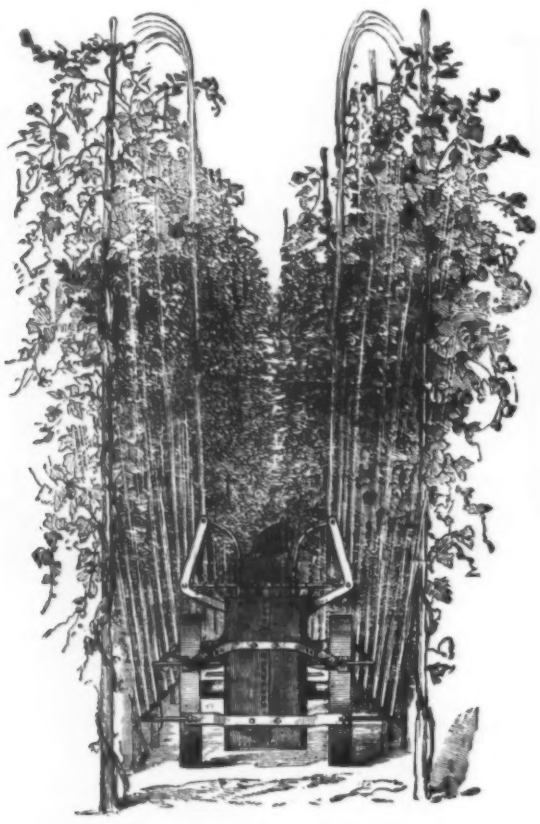


CHIMNEY PRIOR TO STRAIGHTENING.

Solomon Sanderson's acquaintance with the structural peculiarities of these Cyclopean chimneys furnished some curious illustrations of the liberties which may be taken with them by people who know what they are about. The case of one particular chimney shaft, belonging to some works at Bingley, near Bradford, is a pertinent instance. This chimney, which was built at a cost at £2,000, was found, some few years since, to be 4 feet 6 inches out of the perpendicular, presenting, in a somewhat modified form, the appearance of the leaning tower of Pisa, as shown in the accompanying illustration. The inclination was found to be due to the foundations having settled under the vast superincumbent mass of brickwork at one side. Some Yorkshire pundits, who were consulted in the emergency, appear to have advised that excavations should be made under the foundations at the other side until the chimney settled there, too, to the same extent, and so brought itself back into the perpendicular. Under this cunning strategy a well was actually dug beneath the higher side of the shaft, and supplied with water to favor the yielding of the rigid part of the foundation. It fortunately, however, happened that in this stage of the cure, and before the water had had time to accomplish its dangerous work, which would assuredly have been the bringing of the whole structure to the ground, the completion of the rectification was placed in Messrs. Sanderson's hands.

The first step taken under the more scientific management was the restoration of the original state, so far as the foundations were concerned. The well was promptly filled in and made firm with brickwork and concrete, and the perverse superstructure handed over to Messrs. Sanderson's workmen to be dealt with according to the subtle principles of the craft, of which they were the more soundly instructed representatives.

The first step taken was one that seemed to be a proceeding of the rashest temerity. A gap was cut half through the bottom of the shaft on the side where no settlement had taken place. This was managed by removing three courses of the brickwork. This is a proceeding which may generally be safely carried out by experienced and skillful hands. But—and this is perhaps the most astonishing part of the affair—the incision must be made boldly as well as with skill. If it is not carried far enough into the thickness of the shafts the weight on the unsupported side causes a fracture to run through the rest of the brickwork. The misplaced column rights itself with a sudden snap. The central line of the structure acts as a kind of fulcrum across which the strain of the unsupported half of the column comes into play after a lever-like fashion. When, on the other hand, the gap is carried far enough into the brickwork, the unsustained half, under the corrective pull of the gravity of the mass, settles so very gradually and gently back into its place that the opposite half of the shaft yields elastically to the adjusting drag, and no breach of continuity takes place. Experienced operators state that the gap into the columnar shaft must be carried transversely a little beyond the center. In the case of the Bingley chimney, however, additional precautions were taken to secure the success of the operation. As the three courses of brick on the high side of the leaning chimney were cut away, strong screw jacks of iron were inserted perpendicularly into the gap to take upon themselves the duty of sustaining the otherwise unsupported mass of brickwork. The jacks were 10 inches long, and iron plates 1 inch thick were inserted above and below their ends, to serve as temporary platforms. The jacks were inserted one after the other, a few inches apart, as the brickwork was cut away, and each one was adjusted by its regulating screw, so as to come at once into right bearing for sustaining its own share of the superincumbent weight. When the entire gap had been formed, and all the screw props had been inserted, each in its proper place, the jacks were very slowly and gradually shortened as the weight did its work; and when, under the agency of this cautious manipulation, the shaft of the chimney had very nearly settled back into its original perpendicular position, the portions of the gap which lay between the screw props were filled in with solid masonry, the screws were, one after the other, removed, and masonry also put in their place. The making good of the work was commenced before the shaft had quite reached its perpendicular position of permanent repose, because it was known that a slight allowance must be made for a small final compression of the new work after the entire filling in of the gap. The very remarkable operation was carried out in the case of the Bingley chimney with entire success, and the old leaning tower of the sketch is at the present time a straight up-and-down chimney, standing firmly and honestly upon its base, a monumental record of the reparative skill to which it owes its stability as a permanent work.—*Foreman Engineer.*



IMPROVED HOP-WASHING MACHINE.

NEW BLEACHING PROCESS.

THE new process of bleaching vegetable fibers, elaborated and introduced by Jacob Baynes Thompson, although it has scarcely passed the experimental stage, promises to inaugurate some important improvements on existing methods and to put the process on a more scientific basis than it has hitherto stood. So far as we can learn, the process does not necessitate the use of any new materials, but simply varies the method of applying ordinary bleaching materials to the fiber. The method is suggested as the result of an intimate or thorough knowledge of the chemical nature of the fiber to be treated.

The Thompson differs from the ordinary process in that with little labor and trouble it treats the material in one instead of two or more succeeding operations. The goods are prepared by a preliminary boiling in caustic soda. The actual bleaching is effected in a keir connected by pipes with vessels in which the bleaching agents, chloride of lime and carbonic acid gas, are respectively contained. The goods, folded up and in a convenient shape for handling, are placed in the keir, and the chloride of lime is injected and allowed to remain for about five minutes until the material is thoroughly saturated. The liquor is then let off and the carbonic acid gas introduced in a similar manner. The gas is allowed to act on the goods for the space of an hour, in which time the chloride of lime deposited on the fiber will have become sufficiently decomposed. The gas is then withdrawn and a fresh supply of bleach introduced, let off as before, and the gas again admitted and allowed to act as before. The goods are treated alternately in the manner described for about eight or twelve hours, according to the nature of the material under treatment. They are subsequently washed and passed through a bath of triethylrosaniline and oxalic acid, in order to neutralize any remaining traces of the natural color of the cotton.

The chief advantages possessed by or claimed for this process consist (1) in economizing time and labor in handling the goods; (2) in shortening the time required to complete the work; and (3) in securing a better and more uniform result without tendering the goods. These results are attributed to a gradual or continuous method of applying the bleach. The bleach penetrates the material so thoroughly that the heaviest goods can be treated with equal facility and the white is said to develop with great rapidity. The *Textile Monitor* says the process is adapted for either dyeing or printing goods. It is in successful operation in the bleach works of R. Ainsworth, Son & Co. of Bolton, Lancashire. A series of experiments conducted under the supervision of a Mr. Witz, in a printing establishment at Rouen, France, have given highly satisfactory proof of its value in that branch of manufacturing. There are some points yet to considered before the process can be put on a practical basis. The chief of these is the discovery of a more economical method of producing the carbonic-acid gas in quantities suitable for working on an extensive scale.

IMPROVED HOP-WASHING MACHINE.

DRAKE & MUIRHEAD have brought out a new system of hop washing by horse power. The fluid is filled into an iron tank mounted on wheels, and having wrought iron shafts and handles attached. To the driving wheel axle are fitted two high pressure gun metal pumps working inside the tank. The pumps force the liquid through rows of finely drilled pipes at various heights along each side. The washer is driven along the hop alleys, and the liquid is effectually forced up under the leaves and heads of the bines, and thoroughly cleanses them of vermin. One man walking to steer the machine is sufficient to do the work of four or five when hand washing is resorted to, and the work is done more effectually from the increased power of the pumps. Following after the washing it is often found necessary to sulphurate the bines, and they are showing a light sulphurator for the purpose. An improved iron hop press, in which wood is entirely dispensed with and steel employed for the toothed pinions, making it more durable, is also on view.—*Ironmonger.*

FERMENTATION OF INDIGO VATS.

By L. BENOIST.

THE author argues that the reduction of the indigo in the warm vats is effected by anaerobic microbia. Under their influence the sugar is converted into butyric and succinic acids with a plentiful liberation of carbonic acid and hydrogen. The nascent hydrogen fixes itself upon the indigo, and in presence of alkali converts it into soluble indigo-white. Under certain circumstances the bacillus may, if other matters are wanting, destroy the indigo. He therefore breeds one particular *desmobacterium* which he finds most suitable, and sets his vat in such a manner that the bacillus may be nourished at the expense of the starch, which is gradually converted into glucose and protects the coloring matter.

"ANIMAL CHARCOAL."

ANIMAL charcoal, or bone black (Fr. charbon d'os, Ger. Knochenkohle), is pre-eminently the most interesting material coming under the notice of the sugar chemist.

Its history is short but interesting. Lowitz first discovered its decolorizing power in the early days of the present century, but Figuier in 1811 first applied it as a decolorizer, and in the following year Derosne introduced it in the refining of sugar; but it was not until 1822 that its chemical and physical properties were fully investigated by Payen. At the latter date it was employed wholly in the condition of a fine powder, this method continuing until 1830, when Dumont first employed it in the granular state, the sugar liquor being filtered through columns of it. Since those early days many improvements tending toward economy have been instituted, notably the revivification process, by which the same charcoal can be used over many times.* Bone black consists mainly of phosphate of lime ($Ca_3(PO_4)_2$), forming a strong framework for supporting a certain percentage of carbon, and in addition to these it contains carbonate of lime, sulphate of lime, sulphide of lime, iron, and other mineral matter. Its decolorizing power is remarkable, and depends on the presence of the carbon in a state of minute division, supported on the framework of phosphate of lime. Besides its decolorizing power on coloring matter it has an absorptive effect by which many foreign materials, such as soluble organic compounds and metallic salts, are eliminated from the sugar liquors filtering through it.

The importance of the carbon of the bone black may be clearly understood from the fact that the bone without the carbon has no decolorizing power, and conversely pure carbon without the framework of phosphate of lime is *nil* in its action. Again, charcoal carrying 8 per cent. of C is as powerful a decolorizer as one having 10 or 11 per cent., while a gradual increase of carbon as high as 15 to 20 per cent. is accompanied by a corresponding decrease in decolorizing power. The chemist is therefore careful to secure a charcoal that contains no more than 10 per cent. of C.

Among the most deleterious substances present in charcoal, sulphate and sulphide of lime and iron stand permanently first.

The sulphate of lime and the iron are natural constituents of the bone, though iron may sometimes be purposely added to increase its weight. The former often increases very rapidly during the working in the sugar house, thus greatly increasing its density and filling up the pores, thereby decreasing its decolorizing power. The sulphide of lime, on the other hand, increases by the reduction of a portion of the sulphate through the action of the organic materials during the process of revivification, and the sulphide in contact with even a very small percentage of iron produces a greenish color from the subsequent formation of iron sulphide, which imparts a dull color to the lower products of the sugar refiner. Of thirty samples of charcoal from various manufacturers, not more than two have been found free from the sulphide of lime, and none free from iron.

The less sulphates, sulphides, and iron that bone black may contain, the more acceptable it is; all of them increase during the refining of the sugar, so that a new lot of charcoal containing 0·2 per cent. of sulphate of lime, no *sulphide* of lime, and 0·1 per cent of iron is more acceptable for purchase than a lot containing 0·6 per cent., 0 3 per cent., and 0·4 per cent. respectively.

Charcoal generally loses considerable sulphate of lime during the first working in water to which it is subjected, and for the same reason it seldom rises higher than 1 per cent., even when in use for many months; its increase is likewise prevented by the constant addition of new charcoal to the old stock.

The carbonate of lime present in charcoal is a very important factor in refining sugar; new charcoal often contains 8 per cent. of it, and this may decrease from various causes to 4 or 5 per cent., and eventually as low as 2 per cent.; the object of the refiner is to retain just enough of it to act as a neutralizing agent toward the acidity of the liquors filtering through the charcoal—too much alkalinity is more harmful than otherwise.

In regard to the organic matter in charcoal, when present to any great extent it is necessary to obtain a correct estimation of the exact percentage. Various methods have been proposed for its estimation, but many are based on imperfect foundations.

New charcoal should contain none whatever, and when present to the extent of 2 or 3 per cent., it is an indication of an imperfectly burned charcoal.

The sugar refiner keeps a constant eye on the organic matter in the "stock" charcoal. It is continually being subjected to the revivifying process in the kilns, and is afterward examined qualitatively for organic matter by boiling up in caustic potash. By this well known method the smallest amount present is easily detected by the production of a characteristic coloration—a decided yellow; or in case much is present, a dark brown color, whereas well burnt charcoal imparts no color to the caustic solution.

New black offered for purchase should be examined in this way—a dark yellow coloration indicates a "questionable" charcoal.

The processes in B. B. anal. employed by chemists vary with the manipulator. The methods given below are believed to be the most practicable and reliable.

As regards the physical aspects of a charcoal offered for sale, they often indicate sufficiently its quality. A good new charcoal should not weigh over 45 lb. per cubic foot, should present an intense black surface, and adhere tightly to the tongue when the latter is applied to it.

ANALYSIS.

1. *Estimation of the Carbon by Actual Weight.*

Take 3 gr. of the dried and powdered charcoal from the weighing bottle and place in a porcelain evaporating dish with 20 c. c. of distilled water and 25 c. c. concentrated hydrochloric acid. Cover the whole with an inverted glass funnel, and set away for an hour over the smallest possible flame of the Bunsen burner. In the meantime wash a small filter in absolute alcohol and heat in oven at 100 C. for 15 minutes; finally dry and weigh.

The insoluble portion of the charcoal in the porcelain dish consists of pure carbon and insoluble mineral matter. The whole is collected on the weighed filter, washed, dried at 100° C., and weighed. The carbon and insoluble mineral

* And the final result has been to totally exclude the use of blood in the refining of raw sugars. Bone black does the work more thoroughly, and is cheaper and easier to manipulate.

matter with the filter are then transferred to a platinum dish, and the carbon burned off, leaving the insoluble matter. From the loss of weight the carbon is readily calculated, while the residue is sand and clay, etc.

2. *Estimation of the Carbon by Combustion.*

Very accurate results may be obtained by the combustion of charcoal with copper oxide in a hard glass tube. The C is converted into CO_2 and the latter is caught in caustic potash in the usual "potash bulbs." The accuracy of the estimation depends on the accurate estimation of the carbonate of lime, since the CO_2 of the latter must be subtracted from that in the potash bulbs, which contain the total CO_2.

Estimation of the Carbonate of Lime.

Notwithstanding all other methods to contrary, the loss of weight method in CO_2 determined is considered by sugar chemists as the most practical method; any one of the numerous forms of apparatus may be used. Schroetter's apparatus is the one generally regarded as the best from its handy construction.

Into the mouth of the bowl portion of the apparatus insert the neck of a small funnel, and deliver through it 2 grammes of the charcoal from the weighing flask. Then add 5 c. c. of mercuric chloride, in order to retain any sulphur present in form of sulphides. Decompose with H.Cl.

The use of mercuric chloride is of great importance, as the H_2S disengaged by the acid may cause serious errors in accurate estimations.

Bone black often carries a small percentage of free lime (CaO). To determine it, heat 2 grammes in a platinum dish after moistening with water, with a quantity of ammonium carbonate; continue with gentle heat to dryness. Then heat to faint redness for one minute and transfer to the CO_2 apparatus, and determine the total CO_2; from the excess of CO_2 found over that previously obtained, is calculated the CaO.

Estimation of Sulphate of Lime.

Heat one-half the filtrate from the carbon to boiling, and add gradually drop by drop barium chloride till precipitation ceases. Allow to settle half an hour, and filter. From the barium sulphate determine the $CaSO_4$.

Determination of the Iron.

For the other half of the filtrate from the carbon determine first the ferrous iron; supersaturate with sulphuric acid and titrate with permanganate of potash. Then reduce with zinc in an atmosphere of CO_2, and determine the total iron by a second titration; 1 c. c. should oxidize about 0·001 gramme of FeO.

Determination of the Sulphide of Lime.

Weigh off 2 grammes of charcoal and transfer to a porcelain dish. Pour over it 10 c. c. fuming nitric acid, and cover with an inverted funnel. Heat gently for half an hour, add finally hydrochloric acid till all effervescence ceases, heating more slowly meanwhile. Filter, and determine with $BaCl_2$ the total sulphate; from the excess over that previously obtained calculate the sulphide of lime.

Estimation of Phosphate of Lime.

The phosphate of lime is best estimated in the gravimetric way by the use of uranium acetate.

To this end dissolve 0·500 gramme charcoal in dilute HCl. Filter, and make up the filtrate to 500 c.c. with water. Then measure off 50 or 100 c. c., add ammonia to alkaline reaction, and finally acetic acid to acid reaction.

A uranium acetate solution containing 3 gr. of the salt to a liter is sufficient to serve the purpose.

To the portion of the solution measured off add uranium solution till precipitation ceases, the whole meanwhile being brought to a gentle boil. After the precipitation has subsided decant on a filter, and boil the precipitate in water. Decant again and transfer to the filter; dry at 100° C.

Remove the yellow precipitate from the filter and transfer to a weighed crucible, and heat gently; burn the filter, and transfer the ash to the crucible; add 5 drops of fuming nitric acid, evaporate to dryness, and ignite strongly; continue till the contents of the crucible are of a bright canary color. The weight multiplied by 0·1991 = P_2O_5.

Determination of the Organic Matter.

In B. B. the organic matter exists as organic coloring matter.

First prepare the standard solutions as follows:

Select a sample of poorly burnt B. B. (about 20 grammes), and boil up with 20 c. c. caustic potash at 10° B.

Decant the solution on a filter and evaporate the filtrate to dryness. Pour absolute alcohol over the dark organic/potash compound, and heat to boiling over the water bath. Repeat this several times, decanting after each boiling, and finally evaporate to dryness and weigh the residue. After weighing dissolve in hot water, and make up to a large bulk, and determine the alkali by titration with standard acid, using logwood as a decolorizer. From the weight previously found subtract the potash found by the titration. The difference = weight of pure organic matter. Thus a sample of organic matter is obtained with which a solution of pure bleaching powder is to be standardized. To prepare the latter solution, digest in water pure B. powder and make it about 1·030 sp. gr. Then determine the number of c. c. of this required to decolorize the above organic matter in the water solution, and from the results determine the strength of 1 c. c.

To determine the organic matter in any charcoal sample boil up 20 grammes in caustic potash of 10° B., filter, add sulphuric acid to filtrate till only a faint alkalinity is left, and then run in drop by drop the solution of bleaching powder.

To determine water in B. B. weigh off 5 grammes, and heat up to 170° C. for one hour. ALFRED K. GLOVER.

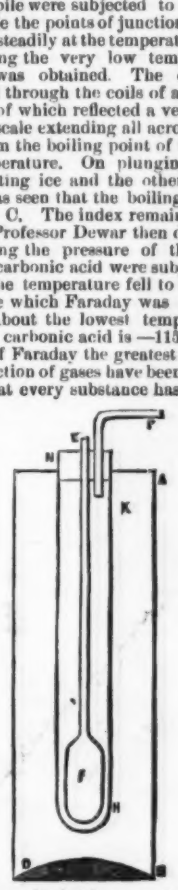
THE LIQUEFACTION OF GASES.

ON June 6 Professor Dewar delivered a lecture at the Royal Institution "On the Liquefaction of Gases." Mr. Warren de la Rue, F.R.S., occupied the chair.

The lecturer said that in the liquefaction of gases most remarkable progress had been made in late years, and having recently had the use of apparatus giving exceptional pressure, presented to the Royal Institution by Mr. De la Rue several years ago, he would try to show some of the results of recent research by scientific men on this subject, although the temperature of the theater was adverse to the experiments. Faraday's plan of liquefying gases was to heat mixtures for generating gases in closed vessels, by which method, for instance, chlorine could be liquefied by pouring hot water over a tube containing a compound capable of liberating that gas. One of the iron bottles near the lecture table contained ten liters of carbonic acid liquefied by compression; he could cause the liquid to chill itself by its own evaporation in escaping from the bottle, so that it condensed into carbonic acid snow which could be collected in a proper receptacle. This solid carbonic acid can be handled with impunity, because it is surrounded by a layer of vapor which keeps it from contact with the skin, which is thereby partially protected from the extreme cold. By subjecting this snow to a pressure of one or one and a half tons to the square inch, it may be compressed into carbonic acid ice, which has to be handled somewhat cautiously. Carbonic acid snow floats on water; carbonic acid ice sinks in water, and comes into contact with the water after a time. A mixture of solid carbonic acid and ether produces intense cold, by which mercury can be frozen with ease.

For measuring very low temperatures the air thermometer is now useless, temperatures having been reached at which air itself is liquefied. Two Russian physicists—Wroblewski and Olszewski—have recently succeeded in liquefying nitrogen, and oxygen has also been liquefied. A convenient thermometer for these low temperatures is therefore wanted; a simple and correct one for the purpose depends upon the production of thermoelectric currents; he therefore used long strips of iron and copper, soldered together at their points of junction, and when those points of junction at one end of the thermo pile were subjected to the action of low temperatures, while the points of junction at the other end of the pile were kept steadily at the temperature of melting ice, a method of indicating the very low temperatures given in the experiments was obtained. The current from this thermo-pile passed through the coils of a reflecting galvanometer, the mirror of which reflected a vertical line of light upon a cardboard scale extending all across the theater; this scale extended from the boiling point of water to the absolute zero of temperature. On plunging one end of the thermo-pile in melting ice and the other in snow carbonic acid in ether, it was seen that the boiling point of carbonic acid was —80 deg. C. The index remained steadily at that part of the scale. Professor Dewar then diminished the temperature by reducing the pressure of the air. When the ether and melting carbonic acid were subjected to the action of the air pump, the temperature fell to —110 deg. C., the lowest temperature which Faraday was able to gain with his appliances. About the lowest temperature obtainable by the use of solid carbonic acid is —115 deg. C.

After the time of Faraday the greatest discoveries in relation to the liquefaction of gases have been made by Andrews, who discovered that every substance has a critical temperature, and he made an absolutely correct record of the pressures, temperatures, and volumes of gases. Professor Dewar then exhibited some liquid carbonic acid near its critical point, when just changing into gas; the tube, a magnified image of which was projected on the screen, seemed to be full of moving striæ. He next exhibited an allotropic form of oxygen, bisulphide of carbon at an extremely low temperature being charged with ozone, which dissolved in it without oxidizing it, and formed a deep blue solution, which became colorless by evaporation of ozone. If the temperature rises sufficiently, combination takes place with explosive violence. Ozone is a blue-colored gas, which can be condensed at very low temperatures and is soluble in carbonic acid and bisulphide of carbon. Nitrous oxide is fluid at a little lower temperature than carbonic acid, and under the air pump it becomes solid; its boiling point is —100 deg. C. A most useful substance for producing low temperatures is liquid ethylene, which had never been previously used in any quantity at the Royal Institution, but on the occasion now under notice Professor Dewar had about 5 lb. weight of it, at a pressure of about 100 atmospheres, made during a fortnight, and contained in an iron bottle surrounded by ice and salt, for it will not remain liquid above 10 deg. C. Ethylene is one of the chief illuminating constituents of coal gas; it can be condensed into a transparent liquid within certain ranges of temperature. The liquid boils at a lower temperature than carbonic acid, and *in vacuo* it gives a temperature lower than any ever before produced in the presence of a Royal Institution auditory.



Professor Dewar then permitted a few ounces of liquid ethylene to flow from its bottle, through a brass tube 7 in. or 8 in. long, kept in a mixture of solid carbonic acid and ether, after which it was passed into the vessel, K H, represented in the accompanying diagram, in which A B is a closed rectangular vessel with glass sides, kept dry inside by phosphoric anhydride at D. An India-rubber cork at N carries the tube, E F, with its flattened bulb, containing the substance to be frozen. P is connected with the air pump to quicken the evaporation of the ethylene. With this arrangement the lecturer froze absolute alcohol, and as it melted it flowed along the tube in a slow, oily manner exactly like glycerine. He also froze ether, bisulphide of carbon, and he liquefied oxygen. The chief difficulties of the lecture were, he said, in the projection of the experiments on the screen, so that all present could see what was taking place. The India-rubber connections also gave trouble; they were frozen as hard as board, and lost all pliability. The evaporating ethylene gave a temperature of —125 deg. C., and when the air pump was applied it fell to —145 deg. or —150 deg. C. By the use of liquid oxygen two Russian chemists have reached the temperature of —200 deg. C., the lowest yet obtained by man. Oxygen boils at about 185 deg. C. Hydrogen has been condensed into a colorless fluid, mobile, transparent, and with no appearance of metallic reflection; its boiling point has not yet been determined, but it is probably somewhere about —200 deg. C. Fluid oxygen has a low refractive index. He saw great probability of these new advances in science being utilized for practical purposes; there was no reason why solid carbonic acid should not be used for putting out fires and other purposes, and it is at present employed in certain instances in steel making, for in water it will get up enormous pressure very quickly. These powers may of course be used for evil as well as good purposes; for a safeguard it is necessary to look to the growth of the moral side of the nature of man.

The listeners were so interested in this lecture that many of them remained for an hour after it was over to see more experiments. In the course of the evening Professor Dewar called attention to the following figures and formulæ:

Critical Temperatures and Pressures.

		Critical temperature T.	Critical pressure P.	T / P
		deg.		
Marsh gas	CH_4	— 99·0	50·0	3·2
Acetylene	C_2H_2	— 37·0	68·0	4·5
Ethylene	C_2H_4	— 10·1	51·0	5·5
Ethylhydride	C_2H_6	— 35·0	45·2	6·8
Amylene	C_5H_{10}	— 191·6	33·9	13·7
Benzol	C_6H_6	— 291·7	60·4	9·3
Chloroform	$CHCl_3$	— 248·0	54·9	9·6
Carbon chloride	CCl_4	— 282·0	57·0	9·0
Carbonic acid	CO_2	— 31·9	77·0	4·0
Bisulphide of carbon	CS_2	— 277·7	78·1	7·0
Cyanogen	C_2N_2	— 124·0	61·7	0·4
Chlorine	Cl	— 141·0	83·9	5·0
Hydrochloric acid	H_2Cl	— 52·2	86·0	3·7
Oxygen	O_2	— 113·0	50·0	3·2
Water	H_2O	— 370·0	195·5	3·5
Hydrogen sulphide	H_2S	— 100·2	92·0	4·0
Ammonia	H_3N	— 130·0	115·0	3·5
Diethylamine	$(C_2H_5)_2N$	— 220·0	38·7	12·7
Nitrous oxide	N_2O	— 35·4	74·0	4·1
Sulphurous acid	SO_2	— 155·4	78·9	5·4

Ranges of Physical Conditions.

	Point of fusion.	Range of liquid.	Range of solid.
	deg.	deg.	deg.
Water	0	370	273
Cyanogen	— 34	158	230
Carbonic acid	— 65	97	208
Sulphurous	— 75	230	98
Ammonia	— 75	294	98
Hydric sulphide	— 85·5	185	187·5
Nitrous oxide	— 100	138	173
Chlorine	— 102	290	171
Carbon sulphide	— 110	386	163
Hydrochloric acid	— 112·5	163	160
Phosphorous chloride	— 114	400	159
Ether	— 117·4	318	155
Alcohol	— 131	365	142
Amyl alcohol	— 134	440	139

Effects of Pressure on Air.

Pressure in atmospheres.	Elevation of temperatures.	Pressure in atmospheres.	Lowering of temperatures.
2	95	½	171
4	221	¼	125
8	389	⅛	166
20	612	1/20	196
22	911	1/21	219

Pressures of Liquid Oxygen.

Temperature.	Pressure in atmospheres.
Centigrade.	
— 129·6	27·22
— 131·6	25·35
— 133·4	24·40
— 134·6	23·18
— 135·9	22·29

— 113 deg. Critical point.
— 50 at. Critical pressure.
Boiling point about — 186 deg.
Density of liquid = 0·90 at — 130 deg.

Boiling Points below the Freezing Point of Water.

	Boiling point below F.P. of water.	Boiling point. Vacuum.
	deg. C.	deg. C.
Carbonic acid	— 80	— 116
Nitrous oxide	— 90	—
Ethylene	— 103	— 142
Oxygen	— 184	— 198
Nitrogen	— 198·1	—
Air	— 192·2	—
Carbonic oxide	— 193	—

Formulæ of Gaseous Laws.

Boyle and Charles $P = \frac{RT}{V}$

Van der Waals $= \frac{RT}{V-b} - \frac{a}{V^2}$

Clausius $= \frac{RT}{V-a} - \frac{\alpha}{T(V+\beta)^2}$

Amagat $= \frac{RT}{V-a} - \frac{M}{V^{m+a}V^{m-4}K}$

Clausius $= \frac{RT}{V-a} - \frac{AT^{-(n-1)} - BT}{(V+\beta)^2}$

Where B, T, and V are symbols of pressure, temperature, and volume, and R, a, a, b, β, &c., are all constants,

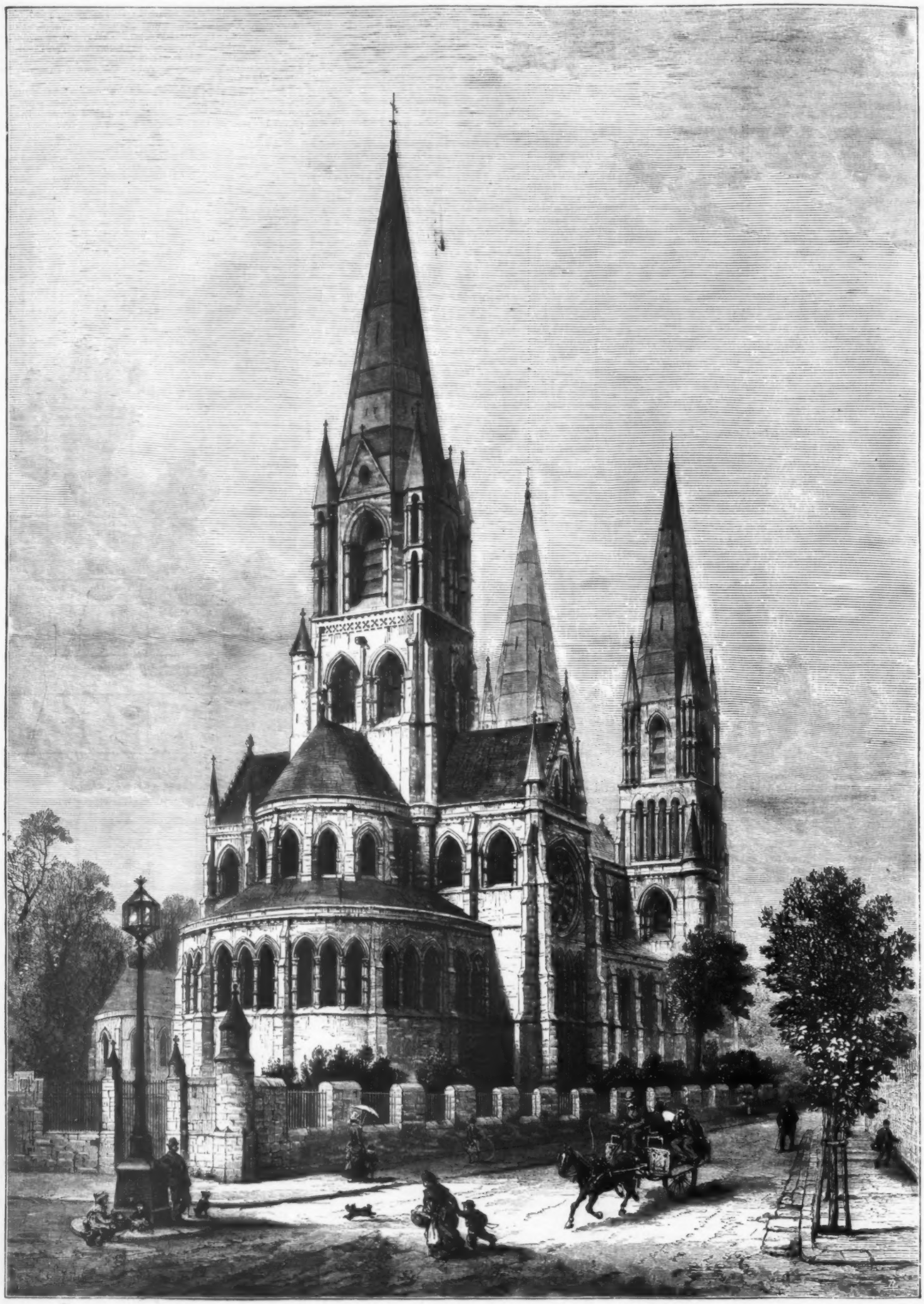
V (1 − P V) = constant (isothermals) Andrews
P (V − −) = " " Amagat.

Fluid Volumes.

1. $V_{max} = b\beta + \sigma\beta^2$, &c.
2. $v = \frac{1}{1-K^2}$. (Mendeleieff)
3. $v = b \log_e (V - \beta)$. (Hallström).

CALIFORNIA LAUGHING GAS.

IT is stated by the *Lundy Index* (California) that "the great Sierra tunnel, at Tioga, has developed the presence, in the indurated mudstone, silicious limestone, and arenaceous shales of Tioga hill, of protoxide of nitrogen, the exhilarating gas known as 'laughing gas,' with traces, also, of the nitrates commonly associated with several of the metals. As is well known, the inhalation of protoxide of nitrogen produces exhilaration to intoxication, an irresistible impulse to muscular exertion, insensibility to pain, and develops the characteristic propensities of the individual to a striking degree. Air is forced in the great Sierra tunnel through wooden boxes, and the distance, leakage, and friction being great, the supply was inadequate, and hence the accumulation of this nitrous gas at the header, the inhalation of which had the characteristic effect upon those working there as soon as one of them got an overdose. A muscular miner was brought out fighting, and it took four men to hold him until he returned to consciousness in the open air. A mail carrier went in and got a dose, and, when brought out, seized a couple of bars of iron, lashed them to his feet with wire, leaped over the dump, and went sailing down the mountain over the snow."



CORK CATHEDRAL.—DRAWN BY THE LATE S. READ.

CORK CATHEDRAL.

THE Cathedral Church of St. Finn Barr, which is the Protestant Episcopalian headquarters of the diocese of Cork, has not much appearance of architectural antiquity. It was mainly rebuilt between the years 1725 and 1735; and for defraying the expense a duty of one shilling per ton was imposed by Act on all coal and culm imported into Cork for fifteen years. The tower only is supposed to be part of the ancient building, erected by Gilla Aeda O'Mugin, in the twelfth century. It is surmounted by a lofty octangular spire of hewn stone, under which is the principal entrance; to the south is the chapter hall, where the consistorial court is held; to the north is the vestry room; the choir is lighted by a fine Venetian window. The Bishop's throne, of black Irish oak, and the prebendal stalls, are handsomely finished, and well arranged. There is a beautiful monument of white marble, to the memory of Chief Baron Tracton, whose body is interred in this cathedral, having been transferred from St. Nicholas' Church. The pointed doorway is recessed, and richly moulded, consisting of an inner and an outer arch, ornamented with clustered columns in relief. The interior, 97 ft. by 57 ft., has a richly paneled ceiling which rests upon ranges of Ionic pillars of scagliola; the north and south galleries are supported by Doric columns. The foundation of the See of Cork is generally ascribed to St. Barr or Finbarr in the early part of the seventh century. His relics, inclosed in a silver shrine, were carried away from the cathedral, in 1089, by Dermot the son of Turlough O'Brian. The diocese includes the county of Cork, extending seventy-four miles in length and sixteen miles in breadth. The cathedral chapter formerly consisted of a dean, precentor, chancellor, treasurer, archdeacon, and the twelve prebendaries of Kilbrogan, Kilbritain, Killaspigmullane, Cabirlog, Liscleary, Killanully, Inniskenny, Kilmaglory, Holy Trinity, St. Michael, Desertmore, and Dromdaleague.—*Illustrated London News.*

THE TWO MANNERS OF MOTION OF WATER.*

By Prof. OSBORNE REYNOLDS.

IT has long been a matter of very general regret with those who are interested in natural philosophy, that in spite of the most strenuous efforts of the ablest mathematicians the theory of fluid motion fits very ill with the actual behavior of fluids, and this for unexplained reasons. The theory itself appears to be very tolerably complete, and affords the means of calculating the results to be expected in almost every case of fluid motion, but while in many cases the theoretical results agree with those actually obtained, in other cases they are altogether different.

If we take a small body, such as a raindrop, moving through the air, the theory gives us the true law of resistance; but if we take a large body, such as a ship moving through the water, the theoretical law of resistance is altogether out; and what is the most unsatisfactory part of the matter is that the theory affords no clew to the reason why it should apply to the one class more than to the other.

When seven years ago I had the honor of lecturing in this room on the then novel subject of vortex motion, I ventured to insist that the reason why such ill success had attended our theoretical efforts was because, owing to the uniform clearness or opacity of water and air, we can see nothing of the internal motion; and while exhibiting the phenomena of vortex rings in water, rendered strikingly apparent by partially coloring the water, but otherwise as strikingly invisible, I ventured to predict that the more general application of this method, which I may call the method of color bands, would reveal clews to those mysteries of fluid motion which had baffled philosophy.

To-night I venture to claim what is at all events a partial verification of that prediction. The fact that we can see as far into fluids as into solids naturally raises the question why the same success should not have been obtained in the case of the theory of fluids as in that of solids. The answer is plain enough. As a rule there is no internal motion in solid bodies, and hence our theory, based on the assumption of relative internal rest, applies to all cases. It is not, however, impossible that an at all events seemingly solid body should have internal motion, and a simple experiment will show that if a class of such bodies existed they would apparently have disobeyed the laws of motion.

These two wooden cubes are apparently just alike, each has a string tied to it. Now if a ball is suspended by a string you all know that it hangs vertically below the point of suspension or swings like a pendulum; you see this one does so, the other you see behaves quite differently, turning up sideways. The effect is very striking so long as you do not know the cause. There is a heavy revolving wheel inside which makes it behave like a top.

Now what I wish you to see is that had such bodies been a work of nature so that we could not see what was going on—if, for instance, apples were of this nature while pears were what they are—the laws of motion would not have been discovered, or if discovered for pears would not have applied to apples, and so would hardly have been thought satisfactory.

Such is the case with fluids. Here are two vessels of water which appear exactly similar, even more so than the solids, because you can see right through them, and there is nothing unreasonable in supposing that the same laws of motion would apply to both vessels. The application of the method of color bands, however, reveals a secret—the water of the one is at rest, while that in the other is in a high state of agitation.

I am speaking of the two manners of motion of water—not because there are only two motions possible; looked at by their general appearance, the motions of water are infinite in number; but what it is my object to make clear to-night is that all the various phenomena of moving water may be divided into two broadly distinct classes, not according to what with uniform fluids are their apparent motions, but according to what are the internal motions of the fluids which are invisible with clear fluids, but which become visible with color bands.

The phenomena to be shown will, I hope, have some interest in themselves, but their intrinsic interest is as nothing compared to their philosophical interest. On this, however, I can but slightly touch. I have already pointed out that the problems of fluid motion may be divided into two classes, those in which the theoretical results agree with the experimental, and those in which they are altogether different. Now what makes the recognition of the two manners of internal motion of fluids so important is that all those problems to which the theory fits belong to the one class of internal motions. The point before us to-night is simple enough, and may be well expressed by analogy. Most of us have more or less familiarity with the motion of troops, and we can well understand that there exists a science of military tactics which treats of the best maneuvers to meet particular circumstances. Suppose this science proceeds on the assumption that the discipline of the troops is perfect, and hence takes no account of such moral effects as may be produced by the presence of an enemy. Such a theory would stand in the same relation to the movements of troops as that of hydrodynamics does to the movements of water. For although only disciplined motion may be recognized in military tactics, troops have another manner of motion when anything disturbs their order. And this is precisely how it is with water; it will move in a perfectly direct, disciplined manner under some circumstances, while under others it becomes a mass of eddies and cross streams, which may be well likened to a whirling, struggling mob, where each individual element is obstructing the others. Nor does the analogy end here. The circumstances which determine whether the motion of troops shall be a march or a scramble are closely analogous to those which determine whether the motion of water shall be direct or sinuous. In both cases there is a certain influence necessary for order; with troops it is discipline; with water it is viscosity or treacliness. The better the discipline of the troops, or the more treacly the fluid, the less likely is steady motion to be disturbed under any circumstances. On the other hand, speed and size are in both cases influences conducive to unsteadiness. The larger the army and the more rapid the evolutions the greater the chance of disorder; so with fluid, the larger the channel and the greater the velocity the more chance of eddies. With troops some evolutions are much more difficult to effect with steadiness than others, and some evolutions which would be perfectly safe on parade would be sheer madness in the presence of an enemy. It is much the same with water.

One of my chief objects in introducing this analogy is to illustrate the fact that even while executing maneuvers in a steady manner there may be a fundamental difference in the condition of the fluid. This is easily realized in the case of troops; difficult and easy maneuvers may be executed in equally steady manners if all goes well, but the conditions of the moving troops are essentially different, for while in the one case any slight disarrangement would be easily rectified, in the other it would inevitably lead to a scramble. The source of such a change in the manner of motion may be ascribed either to the delicacy of the maneuver or to the upsetting disarrangement, but as a matter of fact both these causes are necessary. In the case of extreme delicacy an indefinitely small disturbance, such as is always to be counted upon, will effect the change. Under these circumstances we may well describe the condition of the troops in the simple maneuver as stable, while that in the difficult maneuver is unstable, *i. e.*, will break down on the smallest disarrangement. The small disarrangement is the immediate cause of the breakdown in the same sense as the sound of a voice is sometimes the cause of an avalanche, but since such disarrangement is certain to occur, a condition of instability is the real cause of the change.

All this is exactly true for the motion of water. Supposing no disarrangement, the water would move in the manner indicated in the theory, just as if there were no disturbance an egg would stand on its end; but as there is always some slight disturbance, it is only when the condition of steady motion is more or less stable that it can exist. In addition then to the theories either of military tactics or of hydrodynamics, it is necessary to know under what circumstances the maneuvers of which they treat are stable or unstable. It is in definitely separating these that the method of color bands has done good service, which removes the discredit in which the theory of hydrodynamics has been held.

In the first place, it has shown that the property of viscosity or treacliness possessed more or less by all fluids is the general influence conductive to steadiness, while, on the other hand, space and velocity have the counter influence. Also that the effect of these influences is subject to a perfectly definite law, which is that a particular evolution becomes unstable for a definite value of the viscosity divided by the product of the velocity and space. This law explains a vast number of phenomena which have hitherto appeared paradoxical. One general conclusion is that with sufficiently slow motion all manners of motion are stable.

The effect of viscosity is well shown by introducing a band of colored water across a beaker filled with clear water at rest. Then, when all is quite still, turn the beaker about its axis. The glass turns, but not the water, except that which is quite close to the glass. The colored water which is close to the glass is drawn out into what looks like a long smear, but it is not a smear. It is simply a color band extending from the point in which the color touched the glass in a spiral manner inward; showing that the viscosity is slowly communicating the motion of the glass to the water within. To show this it is only necessary to turn the beaker back, and the smear closes up until the color band assumes its radial position. Throughout this evolution the motion has been quite steady—quite according to the theory.

When water flows steadily, it flows in streams. Water flowing along a pipe is such a stream. This is bounded by the solid surface of the pipe, but if the water is flowing steadily we can imagine the water to be divided by ideal tubes into a fagot of indefinitely small streams, any one of which may be colored without altering its motion, just as one column of infantry may be distinguished from another by color.

If there is internal motion, it is clear that we cannot consider the whole stream bounded by the pipe as a fagot of elementary streams, as the water is continually crossing the pipe from one side to another, any more than we can distinguish the streaks of color in a human stream in the corridor of a theater.

Solid walls are not necessary to form a stream. The jets from a fountain or the cascade in Niagara are streams bounded by free surfaces. A river is a stream half bounded by a solid surface. Streams may be parallel, as in a pipe; converging or diverging, as in conical pipes; or they may be straight and curved. All these circumstances have their influence on stability in the manner indicated in the accompanying diagram.

CIRCUMSTANCES CONDUCIVE TO

Direct or Steady Motion.	*Sinuous or Unsteady Motion.*
(1.) Viscosity or fluid friction, which continually destroys disturbance. Thus treacle is steadier than water.	(5.) Particular variation of velocity across the stream, as when a stream flows through still water.
(2.) A free bounding surface.	(6.) Solid bounding walls.
(3.) Converging solid boundaries.	(7.) Diverging solid bounding walls.
(4.) Curvature of the streams with the velocity greatest on the outside.	(8.) Curvature with the velocity greatest on the inside.

It has for a long time been noticed that a stream of fluid through fluid otherwise at rest is in an unstable condition. It is this instability which renders flames and jets sensitive to the slight disarrangement caused by sound.

I have here a glass vessel of clean water in front of the lantern, so that any color bands will be projected on to the screen. You see the ends of two vertical tubes facing each other; nothing is flowing through these tubes, and the water in the vessel is at rest. I now open two taps, so as to allow a steady stream of colored water to enter at the lower pipe, water flowing out at the upper. The water enters quite steadily, forms a sort of vortex ring at the end, which proceeds across the vessel, and passes out at the lower pipe. The colored stream then extends straight across the vessel, and fills both pipes, you see no motion; it looks like a red glass rod. The red water is, however, flowing slowly, so slowly that viscosity is paramount, and hence the stream is steady. As the speed is increased, a certain wriggling, sinuous motion appears in the column; a little faster, and the column breaks up into beautiful and well defined eddies, and spreads into the surrounding water, which, becoming opaque with color, gradually draws a veil over the experiment. The final breaking up of the column was doubtless determined by some slight vibration in the apparatus, but such vibration, which is always going on, will not affect the stream until it is in a sufficiently unstable condition. The same is true of all streams bounded by standing water.

If the motion is sufficiently slow, according to the size of the stream and the viscosity, the stream is steady and stable. Then at a certain critical velocity, determined by the ratio of the viscosity of the water to the diameter of the stream, the stream becomes unstable. So that under any conditions which involve a stream through surrounding water, the motion becomes unstable at sufficiently great velocities.

Now one of the most noticeable facts in experimental hydrodynamics is the difference in the way in which water flows along contracting and expanding channels. Such channels are now projected on the screen, surrounded and filled with clean, still water. The mouth of the tube at which the water enters is wide; the tube then contracts for some way, then expands again gradually until it is as wide as at the mouth. At present nothing is to be seen of what is going on. On coloring one of the elementary streams, however, outside the mouth, a color band is formed. This color band is drawn in with the surrounding water, and shows what is going on. It enters quite steadily, preserving its clear, streak-like character until it has reached the neck, where convergence ceases; then on entering the expanding channel it is altogether broken up into eddies. Thus the motion is direct and steady in the contracting tube, sinuous in the expanding.

The theory of hydrodynamics affords no clew to the cause of this difference, and even as seen by the method of color bands the reason for the sinuous motion is not obvious. If the current be started suddenly at the first instant, the motion is the same in both parts of the channel. Its changing in the expanding pipe seemed to imply that there the motion is unstable. If this were so, it ought to appear from the theory. I am ashamed to think of the time spent in trying to make this out from the theory without any result. I then had recourse to the method of color again, and found that there is an intermediate stage.

When the tap is first opened, the immediate ensuing motion is nearly the same in both parts; but, while that in the contracting tube maintains its character, that in the expanding changes its character; a vortex ring is formed which, moving forward, leaves the motion behind that of a parallel stream through the surrounding water. When the motion is sufficiently slow, the stream is stable, as already explained; there is then direct motion in both the contracting and expanding portions of the tube, but these are not similar, the first being a fagot of similar elementary contracting streams, the latter being that of one parallel stream through surrounding fluid. The first is a stable form, the second an unstable, and on increasing the velocity the first remains, while the second breaks down, and, as before, the expanding tube is filled with eddies. This experiment is typical of a large class of motions. Whenever fluid flows through a narrow neck, as it approaches the neck it is steady, after passing the neck it is sinuous. The same is produced by an obstacle in the middle of a stream, and virtually the same by the motion of a solid through the water.

The object projected on the screen is not unlike a ship. Here the ship is fixed and the water flowing past it, but the effect would be the same were the ship moving through the water. In the front of the ship the stream is steady, so long as it contracts, until it has passed the middle; you then see the eddies formed as the streams expand again around the stern. It is these eddies which account for the difference between the actual and theoretical resistance of ships.

It appears then that the motion in the expanding channel is sinuous, because the only steady motion is that of a stream through still water. Numerous cases in which the motion is sinuous may be explained in the same way, but not all. If we have a parallel channel, neither contracting nor expanding, the steady moving streams will be a fagot of steady parallel elementary streams all in motion but having different velocities, those in the middle moving the fastest. Here we have a stream, but not through standing water. When this investigation began, it was not known whether such a stream was ever steady; but there was a well known anomally in the resistance encountered in parallel channels. In rivers and all pipes of sensible size experience had shown that the resistance increased as the square of the velocity, whereas in very small pipes, such as represent the smaller veins in animals, Poiseuille had proved that the resistance increased as the velocity. Thus since the resistance would be as the square of the velocity with sinuous motion, and as the velocity in the case of direct motion, it appeared that the discrepancy would be accounted for if it could be shown that the motion becomes unstable at sufficiently large velocities according to the size of the pipe. This has been done. You see on the screen a pipe with its end open. It is surrounded by water, and by opening a tap I can draw the water through it. This makes no difference to the appearance until I color one of the elementary streams, when you see a beautiful streak of color extend all along the pipe. So far the stream has been running steadily, and it appears quite stable. As the speed increases the color band naturally becomes finer, but on reaching a certain speed the color band becomes unsteady and mixes with the surrounding fluid filling the pipe. This sinuous motion comes on at a definite velocity; diminish the velocity ever so little, the band becomes straight and clear, increase it again and it breaks up. This critical speed depends on the size of the tube in the exact inverse ratio, the smaller the tube the greater the velocity. Also the more viscous the fluid the greater the velocity.

* Lecture at the Royal Institution, March 28, 1884.

We have here, then, not only a complete explanation of the difference in the laws of resistance generally experienced and that found by Poiseuille, but also we have complete evidence of the instability of steady streams flowing between solid surfaces. The cause of this instability is not yet completely ascertained, but this much is certain, that while lateral stiffness in the walls of the tube is unimportant, inextensibility or tangential rigidity is essential to the creation of eddies. I cannot show you this, because the only way in which we can produce the necessary condition is by wind blowing over the surface of water. When the wind blows over water, it imparts motion to the surface of the water just as a moving solid surface. Moving in this way the water is not susceptible to eddies, it is unstable, but the result is waves. This is proved by a very old experiment, which has recently attracted considerable notice.

EFFECT OF OIL ON THE SEA.

If oil be put on the surface it spreads out into an indefinitely thin sheet; with only one of the characteristics of a solid surface, it offers resistance, very slight, but still resistance, to extension or contraction. This resistance, slight as it is, is sufficient to entirely alter the character of the motion. It renders the motion of the water unstable internally, and instead of waves what the wind does is to produce eddies beneath the surface. To those who have observed the phenomenon of oil preventing waves, there is probably nothing more striking throughout the region of mechanics. A film of oil so thin that we have no means of illustrating its thickness, and which cannot be perceived except by its effects—which possesses no mechanical properties that can be made apparent to our senses—is yet able to prevent an action involving forces the strongest that we can conceive, able to upset our ships and destroy our coasts. This, however, becomes intelligible when we perceive that the action of the oil is not to calm the sea by sheer force, but merely, as by its moral force, to alter the manner of motion produced by the action of the wind from that of the terrible waves on the surface into the harmless eddies below. The wind brings the water into a highly unstable condition, into what morally we should call a condition of great excitement; the oil by an influence we cannot perceive directs this excitement. This influence, although insensibly small, is however now proved to be of a mechanical kind, and to me it seems that this instance of one of the most powerful mechanical actions of which the forces of Nature are capable being entirely controlled by a mechanical force so slight as to be imperceptible does away with every argument against strictly mechanical sources for what we may call mental and moral forces.

But to return to the instability in parallel channels. This has been the most complete as well as the most definite result of the method of color bands. The circumstances are such as render definite experiments possible; these have been made and reveal a definite law of instability, which law has been tested by reference to all the numerous and important experiments that have been recorded with reference to the law of resistance in pipes, whence it appears that the change in the variation of the resistance from the velocity to the square of the velocity agrees as regards the velocity at which it occurs with the change from stability to instability. It is thus shown that water behaves in exactly the same manner, whether the channel is, as in Poiseuille's experiments, of the size of a hair, or whether it be the size of a water main or of the Mississippi. The only difference being that in order that the motions may be compared the velocities must be inversely as the size of the channels. This is not the only point explained.

If we consider other fluids than water, some fluids like oil or treacle apparently flow more slowly and steadily than water; this however is only in smaller channels. The velocity at which sinuous motion commences increases with the viscosity. Thus while water in ordinary streams is always above its critical velocity and the motion sinuous, the motion of treacle in such streams as we see is below its critical velocity, and the motion is steady. But if Nature had produced rivers of treacle the size of the Thames, the treacle would have flowed as easily as water. Thus in the lava streams from a volcano, although looked at closely the lava has the consistency of a pudding, in the large and rapid streams down the mountain side the lava flows with eddies like water.

There is now only one experiment left. This relates to the effect of curvature in the streams on the stability of the motion. Here again we see the whole effect altered by apparently a very slight cause. If the water be flowing in a bent channel in steady streams, the question as to whether the motion will be stable or not turns on the variation of the velocity across the channel. In front of the lantern is a cylinder with glass ends, so that the light passes through in direction of the axis. The cylinder is full of water, the disk of light on the screen being the light which passes through this water, and is bounded by the circular walls of the cylinder. By means of two tubes temporarily attached, a stream of color is introduced so as to form a color band right across the cylinder, extending from wall to wall; the motion is very slow, and, the taps being closed and the tubes removed, the color-band is practically stationary. The vessel is now caused to revolve about its axis. At first only the walls of the cylinder move, but the color band shows that the water gradually takes up the motion, the streak being wound off at the ends into two spiral lines, but otherwise remaining still and vertical; when the streak is all wound off and the spirals meet in the middle, the whole water is in motion. But as the vessel is revolving, the motion is greatest at the outside, and is thus stable. There are no eddies, although the spiral rings are so close as nearly to touch each other. The vessel stops, and gradually stops the water, beginning at the outside. If this went on steadily, the spirals would be unwound and the streak restored; but as the velocity is now greater toward the center, the motion is unstable for some distance from the outside, and eddies form, breaking up the spirals for a certain distance toward the middle, but leaving the middle revolving steadily. Besides indicating the effect of curvature, this experiment neatly illustrates the action of the earth's surface on the air moving over it, the variation of temperature having much the same effect on the stability of the moving fluid as the curvature of the vessel. The moving air is unstable for a few thousand feet above the earth's surface, and the motion consequently sinuous to this height. The mixing of the lower and upper strata produces the heavy cumulus clouds, but above this the influence of the temperature predominates; the motion is stable, and clouds, if they form, are stratus, like the inner spirals of the color-bands.

THE locusts in several districts of south Russia are committing frightful ravages. In Elizavetgrad the peasants have just received a reward from the Imperial Agricultural Society for the destruction of 1,700,000 of these insects.

A NOVEL GLOBE VALVE.

OUR engraving represents a globe valve by Miller of Prague, which was the outcome of the desire to construct a cheap and light valve of large diameter. As shown it consists of two hemispheres of spun metal, which have necks spun in them and flanges attached, the thickness of the sheet metal corresponding to the pressure to which the valve is subjected. The two hemispheres are bolted together by means of their flanges, which support a disk that carries the valve-seat and the standard through which the spindle

A NOVEL GLOBE VALVE.

passes; it will be apparent that this arrangement relieves the casing of all strain.

By referring to the figure it will be seen that by revolving hemisphere, A, through an angle of 180° an elbow is formed, as shown by the dotted lines; and by varying the angle of revolution any desired inclination can be obtained. The spindle passes through a stuffing-box, and the bottom of the valve is provided with a small stop cock. The latter allows the drawing off of condensed liquid, and also permits the valve to be tested for leaks. The valve has a large opening compared with its diameter, and its weight is from 50 per cent. to 80 per cent. less than those of cast iron of the same size. According to the nature of the fluid, the valve and seat may consist of phosphor-bronze, rubber, or iron.—*Neu. Erf. u. Erf.*

IMPROVED PUMPING ENGINES.

WE give below a perspective view of the pair of powerful centrifugal pumping engines exhibited by the makers, Messrs. Simpson & Co., of Grosvenor road, Pimlico, S. W., at the International Health Exhibition, London. These engines form one of four sets which Messrs. Simpson & Co. are making for the four new graving docks of the East and West India Dock Company at Tilbury, of which docks Mr. A. Manning and Mr. D. Barnes are the engineers. The four sets of engines will be together capable of discharging 650 tons, or 145 600 gallons, per minute, a quantity equal to a stream about 77 ft. wide by 3 ft. deep running at a speed of three miles per hour.

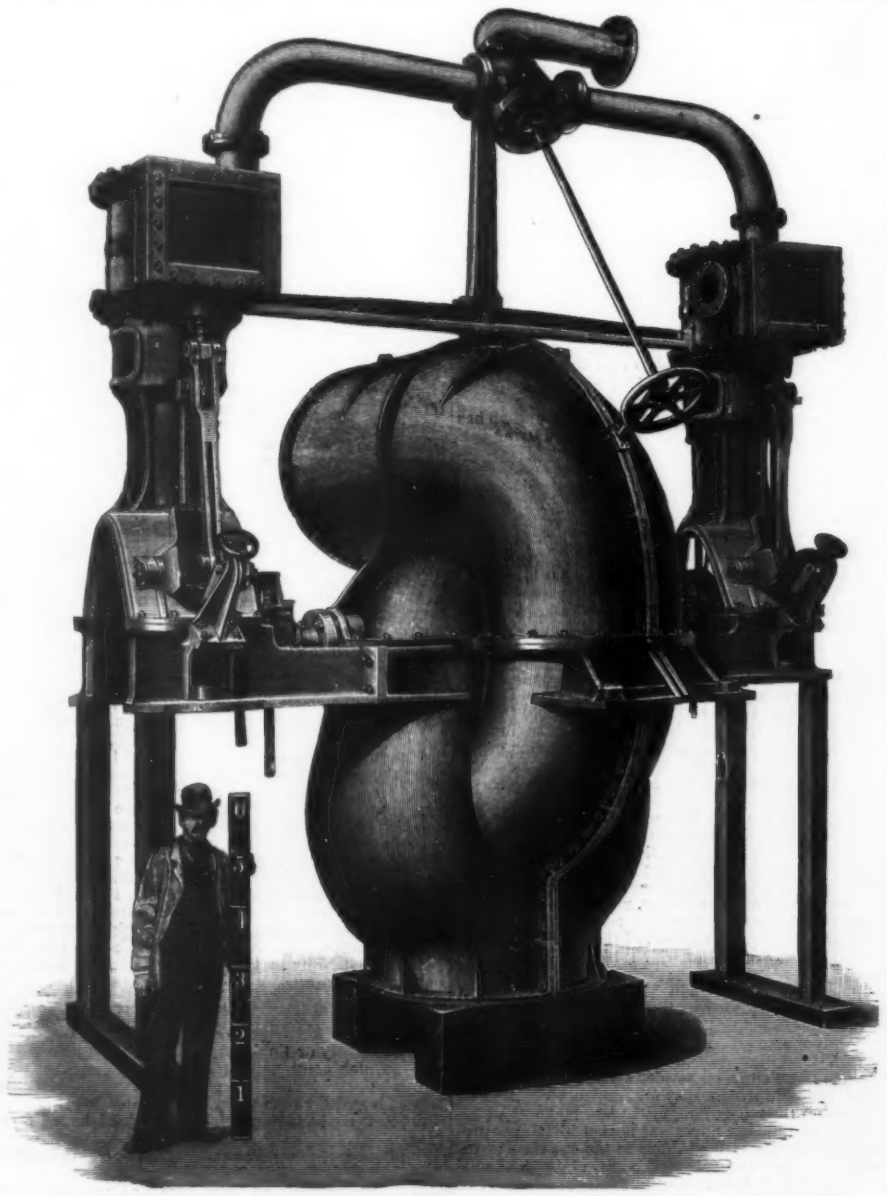
Referring to the engraving, it will be seen that the pump is driven by a pair of engines coupled direct to the ends of the pump spindle these engines having cylinders 22 in. in diameter and 16½ in. stroke. They are of substantial, straightforward design, and are fitted with Joy's valve gear, thus enabling the degree of expansion to be adjusted. The pump has a suction pipe 4 ft in diameter, enlarging to 7 ft., and a delivery pipe 3 ft. 8 in. in diameter tapering to 4 ft. 11¼ in. in diameter.

Steam will be supplied to the four sets of pumping engines by four Lancashire boilers, the furnace tubes of which lead to a combustion chamber, from which tubes are carried through to the rear end. The boilers will be placed in a closed stokehole, and the combustion will be urged by air under pressure supplied by fans. This is, we believe, the first installation on land of boilers thus worked, and the results will be waited for with great interest. No doubt experiments will be made to test the evaporative efficiency of the boilers under various air pressures, the arrangements at Tilbury being such as to enable experiments of this kind to be carried out with readiness and accuracy. The data thus obtained will be of great value and interest, and we hope at a future time to be able to lay them before our readers. We may mention in conclusion that the arrangement of pump we illustrate is one which appears well fitted for use for irrigation purposes in India or Egypt.—*Engineering.*

THE GARDNER GUN.

THE employment of machine guns in the army as well as in the navy has long occupied the attention of all European Governments. In June, 1880, the British Government ordered a Select Committee to examine all the existing systems of machine guns. After exhaustive trials the Committee, on the 21st March, 1881, reported that out of ten points, on which each of the different machine guns were compared, on nine of these points the "Gardner" guns were preferred; and the Committee recommended the adoption of the two-barrel Gardner gun for both services; and, where a more powerful gun is desired, the adoption of the five-barrel Gardner gun. Large quantities of these guns have since been purchased by the Government, and their efficiency and value have been clearly proved in the Soudan at the battles of El Teb and Tamasi, where they did great execution, thus clearly bearing out the Select Committee's report.

The working of the gun is as follows: The bullet ends of the cartridges are inserted in a perforated wooden block, and are thus conveyed to the "reservoir" of the gun. This "reservoir" has a flanged way, or a T groove, which holds



IMPROVED PUMPING ENGINES.

the cartridges by the head or rim, and the cartridges fall by gravity to their place at the rear end of the barrels. The turning of the handle, or hand crank, actuates the simple mechanism, and the "plungers" push the cartridges into the barrels, where they are discharged, while the continuous rotation of the crank extracts the empty shell of cartridge. In the one and two-barrel gun, the empty shells are expelled through orifices at the side of the gun, and in the five barrel gun they are withdrawn from the rear end of the barrels, and are forced through apertures in the cartridge rest, and fall to the ground nearly vertically. The speed in the rotation of the hand crank necessarily gives the rapidity of fire. The one barrel gun has been fired at the rate of 300 shots per minute, the two barrel at 600, and the five barrel at 1,200. The cartridges fall by gravity, but gravity is always accelerated by the firing of the gun, and by the insertion of new cartridges.—*London Graphic.*

THE GARDNER PORTABLE MACHINE GUN.

IMPROVEMENTS OF THE LOCOMOTIVE.

AT the late annual convention of the Master Mechanics' Association Mr. Alex. Mitchell, Superintendent of the Lehigh Valley Railroad, furnished the committee with a photograph of a locomotive designed by him for heavy mountain service. The design of this engine is shown in the accompanying illustration from *The Railroad Gazette*, and the general dimensions of the engine are as follows:

Boiler, diameter at front end.....	54 in.
" material.....	Otis steel.
Fire-box, length.....	11 feet.
Flues, diameter outside.....	2 in.
" number and length.....	238, 12 ft.
Cylinders, diameter and stroke.....	20 in. × 26 in.
Driving-wheels, diameter.....	50 in.
Weight.....	108,000 lb.

The first, second, and third pair of drivers have flanged tires, while the fourth or rear drivers have plain tires 7 in. wide. The single wheel or pony truck in front is loaded with 5½ tons, and the similar back truck with 4½ tons. The object has been to get a large engine for heavy service with a short, rigid wheel-base. The front truck is equalized with the first and second pair of drivers, the third and fourth pairs are equalized, and the rear truck takes its own weight, having a deep pocket with long spiral springs on the center plate and volute springs over the boxes.

Mr. Mitchell says that the engine runs round curves with great ease, and is hauling very heavy trains, but no accurate data can yet be given. Blue prints of designs for somewhat similar engines, but with five instead of four pairs of coupled wheels, show the relations between the wheels and rails on a curve of 330 ft. radius. In one design, the first, third, and fifth pair of driver tires (counting from the front end of the engine) are plain, while the second and fourth pairs are flanged. The rigid wheel-base is thus only 8 ft. 3 in., though the total driving-wheel base is no less than 16 ft. 11 in., and the total wheel-base of the engine, from center to center of pony truck wheels, is 31 ft., an unprecedented length. The other design has the same distances between the wheels, but the first and fourth pairs of drivers are flanged, and have ½ in. side play in the boxes. The remaining three pairs of drivers have plain tires, 6½ in. and 7 in. wide, according to position.

THE DISTRIBUTION OF STEAM IN CITIES.

IN reply to criticisms on the distribution of steam in cities, contained in a paper by W. A. Goodyear, read before the Boston meeting of the Institute of Mining Engineers, Mr. W. P. Shinn has, in a communication to the Institute, given some facts that are of general interest. We quote the following from his paper:

The system of steam distribution invented by Birdsill Holly, M.E., has been in successful operation in Lockport, New York, for heating only, for seven years. The company has four and a half miles of main, six 75 horse-power boilers, and supplies over two hundred consumers. During the first four years, it was operated without meters, at a loss. When meters were adopted, three boilers were sufficient to supply the customers who formerly required the steam from six. The capital of the company is $50,000, and it is earning net from 20 to 25 per cent. per annum. The largest main is 4 inches in diameter, and the pressure carried is from 30 to 35 pounds.

In Springfield, Mass., the system has been in use for five winters, for heating only. The company has two and a quarter miles of mains, and eight 75 horse-power boilers. The pressure carried is from 20 to 40 pounds. The company has 196 consumers, and on an investment of $50,000 has earned net from 12 to 15 per cent. per annum, since the second year. The steam is sold by meter, and readings are taken weekly.

In Dubuque, Iowa, the system has been in operation for five winters, with two and one-eighth miles of mains, and seven 50 horse-power boilers. The company is supplying 250 horse-power of steam to 140 consumers for heating purposes only. The plant was constructed too cheaply, and has not been a financial success. It is now earning a small surplus, and consumers are all delighted with the service.

In Denver, Colorado, the system has been in use during four years, for heating only. The company has nearly three miles of eight, six, four, and three-inch mains, and fifteen 50 horse-power boilers, supplying 150 consumers. Upon an investment of $150,000, the company earned net, during the season of 1882–83, $7,863, or 5·2 per cent, and the net savings for the season of 1883–84 were estimated at $10,000, or 6⅔ per cent.

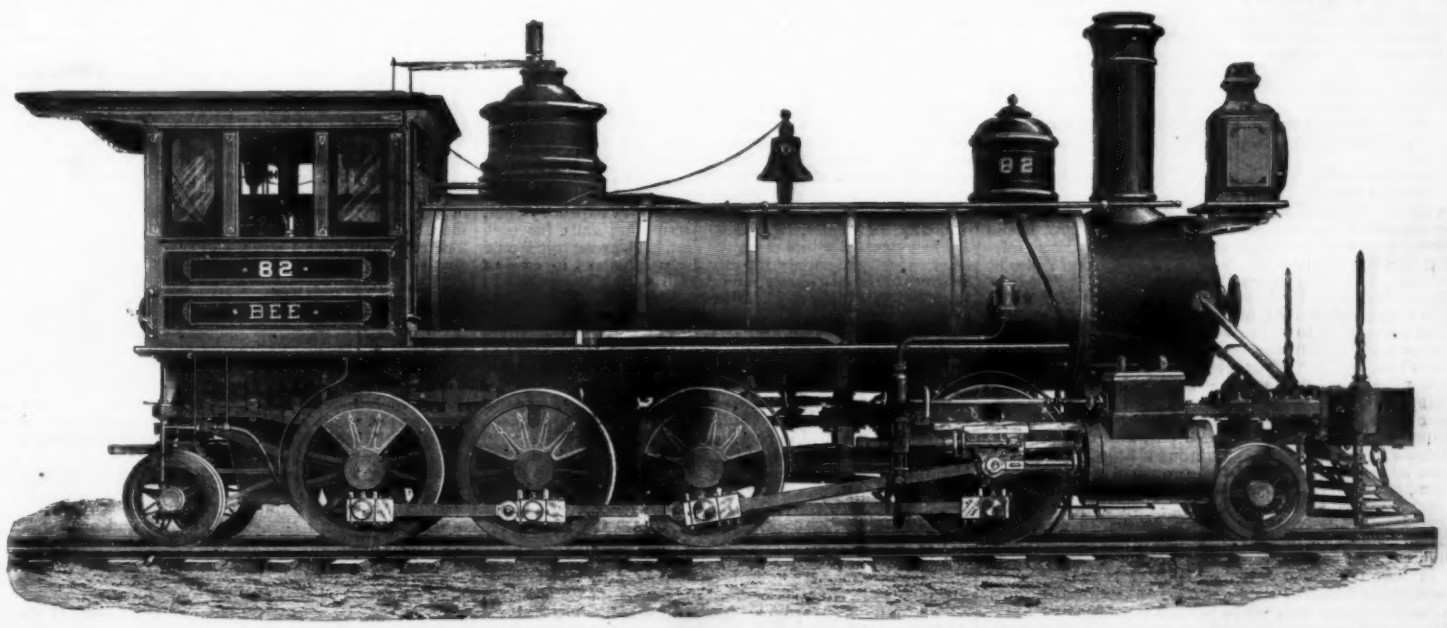
In Hartford, Conn., a steam-plant has been in operation during four seasons, with nearly two miles of 6-inch, 4-inch, and 3-inch mains, and twenty 80 horse-power boilers. This company carries 60 pounds pressure, and supplies 150 consumers, principally for heating. The plant was poorly constructed upon plans designed to evade the Holly patents, and has not been profitable, but is paying expenses, and improving in its results.

In Lynn, Mass., a "duplex system" was put in operation in February, 1881, and was run until July, 1883. This plant had a high-pressure main in which 70 pounds pressure was carried, and a low-pressure main carrying 20 pounds, the former being used for power and the latter for heating. I personally examined this plant in October, 1881, and again in June, 1882, and found it working successfully and giving great satisfaction to its customers for power, the only ones then using the steam. The plant was poorly constructed, the boiler-house was badly located, and the company failed financially; and in July, 1883, the plant was sold to a company, to be used for the distribution of water-gas. It has been so used during the heating season just ending, with a less favorable result than was reached by the steam company.

In New Haven, Conn., a company has been in operation for two seasons, with about two miles of 8-inch, 6-inch, 5-inch, and 4-inch mains, and ten 75 horse-power boilers. The plant was constructed on the "duplex plan," and during the first season furnished both power and heat; but during the past season it has furnished 500 horse-power of steam to 80 consumers for heating only. The financial results have been bad, the earnings having failed to pay expenses, principally on account of bad management.

In Troy, N. Y., and Detroit, Mich., steam-plants have been in operation from three to four years; but I have no definite information as to their results.

In Milwaukee, Wis., a plant was constructed and operated during two winters; but owing to faulty construction and still worse management, it was a financial failure; and it has not been in operation during the last two seasons.



IMPROVED LOCOMOTIVE FOR LEHIGH VALLEY RAILROAD

The New York Steam Company, after two years spent in making plans and trying experiments in expansion-joints and in non-conducting materials, began building its first boiler-station in the summer of 1881, and commenced laying street-mains in September, 1882.

The company now has its boiler-station (B) on Greenwich street above Cortlandt, in this city (a building 75 by 100 feet on the ground, with a basement and three stories complete, and the fourth story covered by a temporary roof), containing 31 Babcock & Wilcox 250 horse-power boilers, of which there are on the first floor 4, on the second floor 12, and on the third floor 15. The fourth floor contains the coal-bins, the coal being hoisted in cars, upon a platform-hoist, and descending in chutes to the floor, alongside each boiler. The building is designed to be six stories, or 120 feet in, height above the basement, and is to contain 64 boilers of 250 horse-power each, 16 on each of four floors, the fifth and sixth stories to be in one, to contain Green's economizers, and storage for one thousand tons of coal. The total capacity of the station will be 16,000 horse-power, requiring a daily consumption of from 600 to 750 tons of anthracite coal. Draught will be furnished by two chimneys, each 27 feet 10 inches by 8 feet 4 inches interior section, and 217 feet high above the basement floor. The grant to the company covers the right to lay its pipes in "every street, alley, and public place" in the city of New York, which contains over 350 miles of paved streets; and the company now owns the property for ten boiler-stations, distributed on both sides of the city, from near the foot of Broad street to Fifty-sixth street. The system of mains consists of a steam-main of from 6 inches to 16 inches in diameter, and a return water-main of from 2½ inches to 8 inches diameter, the former laid between brick walls, and surrounded by from 6 inches to 12 inches of mineral wool, and the latter laid in hollow logs, with a space of 3 inches around the pipes, also filled with mineral wool. The pipes are laid with an anchorage every 90 to 100 feet, and a double expansion joint midway between the anchorages—or with an anchorage and single expansion joint every 45 to 50 feet. The expansion joint is of the diaphragm style, invented by Mr. Emery for this company's use.

The mains now laid are as follows:

STEAM MAINS.

Of 16 inches	746	feet.
15 "	9,884	"
13 "	1,683	"
11 "	4,147	"
8 "	1,091	"
6 "	5,802	"
Total	23,353	feet.

RETURN WATER-MAINS.

Of 6 inches	5,037	feet.
5 "	1,155	"
4 "	11,900	"
2½ "	3,800	"
Total	21,892	feet.

Or 4·42 miles of steam-mains, and 4·14 miles of return mains, in all 8 56 miles of pipes, exclusive of service-pipes. The most distant point to which steam is now delivered is 3,359 feet from the boiler station; and the other extremities are 3,187, 3,133, 3,044, 2,973, 2,920, 2,880, 2,625, 2,261, and 2,077 feet respectively, from the boiler station. The pressure carried is from 75 to 85 pounds at the boiler station, and carefully conducted tests show the pressure at the extreme points to be from 1½ to 2 pounds less than at the boiler station. The company has been furnishing, during March, 1884, 4,156 horse-power of steam to consumers, of which 1,985 horse-power was for power, 2,171 horse-power for heating and other purposes. Engines are run of from 1 to 150 horse-power, and the supply of steam is regular, constant, and satisfactory. The amount of capital actually invested in the Station B and its street-system is $1,086,320.79. Only one-half the capacity is at present utilized; but the operations are now on a paying basis, the net earnings being at the rate of $320,000 per annum, or about 2 per cent. of the cost, and this in the second year of operation. When Station B is operated at its full capacity, much greater economy will be realized, and its net earnings are expected to be from 15 to 20 per cent. on the amount of the investment in that part of the company's system.

I claim, therefore, that the system of street distribution of steam in cities is not a failure, but that, considering the limited time for which it has been tried, it is a decided—an *unusually* decided—success.

WATER SUPPLY.

MR. C. H. M. BLAKE, in a communication to the *Mexican Financier*, urges the importance of improved water works for Mexican towns and cities. He says:

The question of adequate supply of pure water is vital to the interests of all cities. The source of supply must vary according to local circumstances, and may be classed under the following heads:

1. Water stored in reservoirs during the rainy season.
2. Never failing streams.
3. Springs.
4. Artesian wells.
5. Ground water.

In Mexico the first method is most objectionable, as the long continued dry season, during which no flow would enter the reservoir, would cause the water to become inferior in quality, and the loss by evaporation would also be immense. The evaporation from reservoirs in the New England States is greatest during August, during which month it aggregates four inches in depth. In the absence of data I assume it to be in Mexico, on an average, no less per month, giving four feet in depth to be provided annually for this loss, and these four feet being from the water *surface* would amount to a much greater depth were an equal amount taken from the contracted area at a lower depth. Where circumstances compel storage reservoirs as the source of supply, all the water should be filtered before entering the distribution pipes. Filtration through beds composed of broken stone or gravel, about the size of a hen's egg at the bottom, with layers gradually decreasing in size to fine sand at the top, the water being flowed in the sand and gathered into drains at the bottom of the filter bed, will remove matters in suspension in the water. These beds will filter about 90 gallons per day per square foot of area, or, in round numbers, 1,000 gallons per square meter. About one-half inch of the layer must be removed occasionally, as it clogs up with the impurities retained.

The second and third methods for securing a supply may be considered together. The quality of the water would determine the preference, but probably in but few cases will any single stream or spring furnish an adequate supply during the dry season, and the objections against storage of water in the first case would apply, in a modified form, to utilizing water by means of storage, in large quantities, in any event.

ARTESIAN WELLS.

Many persons who have not investigated the conditions necessary to procure water by means of artesian flowing wells assume that it is only a question of the depth the well is driven when an abundant supply will be secured. No idea in connection with water supply is more fallacious. The geological and topographical conditions necessary for success in this case are extremely easily understood, but not generally known by the general public. Suppose a soup plate to be placed in another, and the intervening space filled with water. Then bore a hole through the upper plate, and a flow will result until a hydrostatic equilibrium is obtained. This is the whole theory of artesian wells. They can only exist when the water is derived from an elevation above the ground where the well is located, and the water bearing stratum confined between impervious strata, such as clay. In the above case the hydrostatic pressure from the source forces the water to the surface. Any attempt to obtain water for cities in the mountains by means of artesian wells will be a hazardous expenditure of money with no certainty of success. While it is possible water may be obtained by this method, it is by no means certain what the *quality* would be in the event of success.

GROUND WATER.

We now have the last method of supply to discuss, viz., ground water, by which is meant water secured by means of large excavations, afterwards covered, in most cases to prevent the deleterious effects of the action caused by exposure to the sun. The most favorable material for the storage of water in the ground is coarse gravel, which contains about 30 per cent. of void spaces, that is, a cubic meter saturated with water will contain about 80 gallons. When a sufficient area of good water-bearing strata can be obtained, and the quality of the water is good, it is the best source from which to obtain a supply in this country, for the following reasons:

1. It is not exposed to the sun, and therefore the evaporation is slight, and no deleterious vegetable or animal growths will be generated.
2. It is filtered by nature in its passage through the earth.
3. When situated favorably, it is not subject to either vegetable or organic contamination.

Before determining the source of supply, careful consideration must be given to all conditions affecting the success of the project. Too hasty a conclusion in this matter may cause a large expenditure of money, followed by the ultimate failure of the works to furnish an adequate supply.

The fact of the water being *below* the level of the city should not be considered as objectionable if it be superior to another source where it could be delivered by gravity. The cost of pumping into a reservoir in the United States, including fuel, attendance, repairs, and interest on the cost of plant, with coal at $7.00 per ton, and an engine of fair "duty," does not exceed $10.00 per million galls. for each 100 ft. the water is elevated. In Mexico the expense would, of course, be greater, but $20.00 per million galls. for each 100 feet elevated would cover the cost. The reservoir should be of capacity to supply the city for a few days in case of accident to the machinery, and would permit the engine to work to its full capacity. Direct pumping into the pipes or the use of a "stand pipe" is extremely expensive, as the engine must be constantly at work; requiring a double set of attendants, supplying water under great fluctuations of demand, and rendering duplicate machinery necessary to provide for accidents. With a good engine, pumping into a reservoir, 1,000 lb. of coal should pump 1,000,000 galls. 100 ft. high. In the near future, I understand, the Mexican Central Railway will import coal as an important factor of their freight, which will enable manufacturers and others to obtain it at reasonable prices on the lines of the railways of the Republic.

EFFECTS OF SANITARY WORKS ON THE DEATH RATE CAUSED BY ZYMOTIC DISEASES.

The principal diseases due to the lack of pure water and effective sewerage are termed zymotic, and include typhoid fever, phthisis, diphtheria, etc. Following the construction of works of water supply and sewerage, the total annual death rate in Mexican mountain cities should not exceed in any case, 20 per one thousand inhabitants, and probably with the exceptionally healthy climate of the plateau and mountains of Mexico would be reduced to fifteen. As an illustration of the reduction of deaths from the principal zymotic diseases where such works have been built, the following statistics are instructive, the places being all English cities or towns:

Place.	Reduction in deaths from typhoid fever, per cent.	Reduction in deaths from phthisis, per cent.
Banbury	48	41
Cardiff	40	17
Corydon	63	17
Leicester	48	33
Macclesfield	48	31
Merthyr	60	11
Salisbury	75	49
Warwick	53	19

In no cases were the above places in so bad a sanitary condition, previous to the construction of the works, as the Mexican cities under discussion; it is therefore certain that sanitary improvements, in the latter cases, would make a greater saving in the percentage of death rates than in any of the examples given. Capitalists in the United States would be glad to construct water-works in many Mexican cities, as a profitable investment, if the municipal authorities would meet them half way and grant concessions which would protect the capital invested, but the failure of the authorities to appreciate the benefits offered and defer prompt action will turn the attention of investors in other directions.

MINCHIN'S ABSOLUTE SINUS ELECTROMETER.

THIS new and excellent instrument has just been completed, and is now ready for operation in laboratories or shops. Its great advantage over Sir William Thomson's absolute galvanometer is that it does not require a constant change, and, moreover, that it is capable of measuring electromotive force from that of a single Daniell element up to 180 volts, while Thomson's is only capable of measuring relatively high differences of potentials. Prof. Minchin has invented an apparatus that combines convenience of manipulation with great sensitiveness. The apparatus consists principally of two parallel

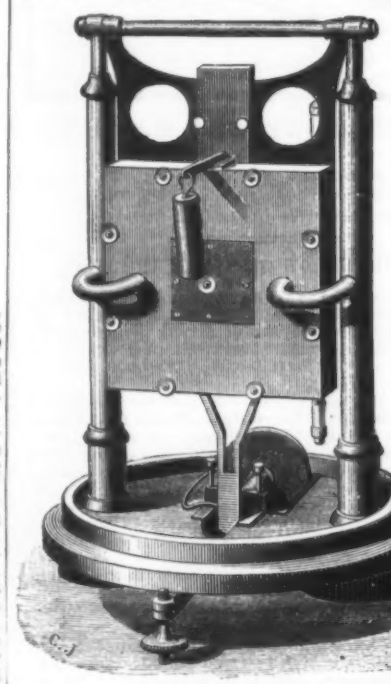


FIG. 1.

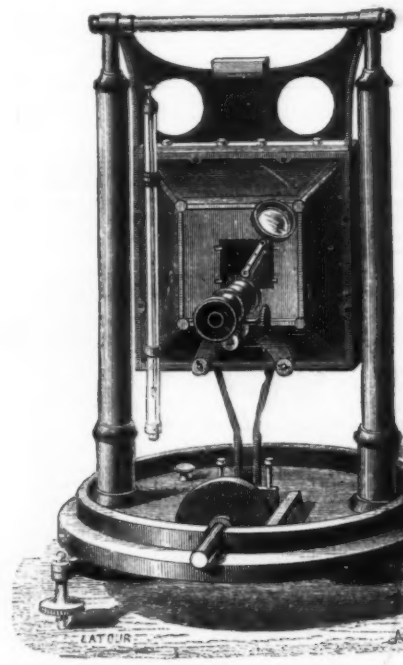


FIG. 2.

MINCHIN'S ABSOLUTE SINUS ELECTROMETER.

metallic plates, which are suspended vertically from a frame in such a way that they can be deflected to a certain angle from the vertical by means of an adjusting screw (Figs. 1 and 2). In the middle of one of these plates there is an aperture which is nearly closed by a trap-shaped door of sheet magnesium, which, although 4 cm. square, weighs but a few grains. This door is suspended by three fine platinum wires from the upper edge of the perforated plate or guard. When the disk or door is on a level with its guard plate it rests upon the extremity of four fine screws, and is then at a distance of half a millimeter from the continuous plate situated in front. The two plates are each nearly a foot square, and are connected together by four ivory axes placed near the corners. These axes are fixed into pieces of ebonite that are set into each plate. Mica rings, half a millimeter in thickness, are placed between the plates and serve to keep them at a certain distance from each other. The two attached plates may be moved around their one axis in common by means of a micrometer screw, which is divided into sixtieths of an inch, and the head of which is divided into 1,000 equal parts. The extremity of this screw touches the lower part of the guard plate at a distance of 15 inches above the suspension axis. In order to make an observation, the disk is regulated in the same vertical plane as the two plates. The system of plates is then moved arbitrarily around the axis by means of the micrometer screw, and the positive pole of the pile to be measured is connected with the continuous plate and the negative pole with guard plate and disk. Then the screw is turned until the disk or door is just detached from the four screw points upon which it rests—a fact that is ascertained by means of a microscope affixed to the guard plate behind the disk. Then, before making a new observation, a few pile elements are added or subtracted. If

E = the electromotive force of one element in absolute measurement,
m = the number of elements, at the first observation,
n = the number of elements at the second observation;—

we shall have

$$(m^2 - n^2)\, E^2 = K\Delta,$$

a formula in which

K = a known constant, and
Δ = the difference of the circular measurements of the two angles of deflection from the vertical indicated by the movements of the screw.

In the limiting position of the disk's equilibrium the electrical attraction is proportional to the sinus of deflection of the angle made with the vertical, and this is why the instrument has been named an absolute sinus-electrometer. The sensitiveness of the apparatus is so great that if twenty Daniell elements were connected with it, the addition of a single element would give a measurable observation through which its electromotive force could be determined.

The elements adopted for temporarily changing the plates are small Minotto ones, each composed of a copper disk placed in the bottom of a glass vessel about 2 inches square and 4 in height. Above, there is a layer of powdered sulphate of copper and sawdust moistened with sulphate of zinc. Finally, there is a round zinc stopper of sufficient weight to cause it to bury itself well in the sawdust and form a good contact. Two hundred of such elements do not occupy much space, and may be placed in a box 3 feet long, 2 feet wide, and 4 or 5 inches deep. They do very well for the object for which they are intended, that of giving a constant electromotive force, and may prove useful, for example, for making tests of potentials and submarine cables. At present, chloride of silver elements and Clark's standard elements are being used for these operations; but they are relatively expensive, since one chloride of silver element costs about 3 shillings, while the above described Minotto element may be made at an expense of 6 pence.

The interior of the electrometer is kept dry by inclosing the plates in a brass box that acts as an induction screen, and by allowing the internal air to communicate with a reservoir of sulphuric acid by means of a flexible rubber tube that in no wise interferes with the movements of the plates and box. The acid has the well known property of absorbing moisture from the air, and was applied some years ago by Sir W. Thomson to his absolute electrometers at Glasgow.—*La Lumiere Electrique.*

DR. KOHLRAUSCH'S APPARATUS FOR MAGNETIC AND ELECTRIC MEASUREMENTS.

MR. E. HARTMANN, of Wurzbourg, has, under the instructions of Dr. F. Kohlrausch, constructed a series of apparatus for magnetic and electric measurements, the new arrangements of which merit a description. We shall first describe the magnetometer.

The magnetism of several metals, which it is difficult to control, is a notable source of error in magnetic and electric measurements. Thus, for instance, commercial copper becomes magnetic in the vicinity of strong magnets, because it contains iron, although the quantity may be small. Electrolytic copper, on the contrary, shows itself to be diamagnetic, and distinctly repels strongly magnetized needles. Did we desire to alloy copper with a suitable proportion of iron or nickel, so that it should be neither magnetic nor diamagnetic, we should experience a great practical difficulty. It therefore becomes necessary in the construction of sensitive apparatus designed for absolute measurements to avoid using metals in the vicinity of the magnetized needle. In order to deaden the oscillations we may employ Toepler's device. Fig. 1 represents the magnetized steel mirror magnetometer—an instrument which is constructed entirely of wood with the exception of a few copper parts that are quite distant from the needle. The deadener, which is connected by a copper wire with the magnetized needle, oscillates in a glass cylinder, V, which is divided into two compartments so as to increase the friction of the air. To prevent the glass from becoming electrified by occasional friction, and acting upon the vane as do the quadrants upon the needle in Thomson's electrometer, the vessel is silvered, and provided with a few apertures so as to allow the vane to be seen. This latter is formed of copper wire bent into the shape of a square and covered with thin paper. The glass cylinder is 50 mm. in height, and 50 mm. in diameter. With this device the coefficient of retardation in two consecutive oscillations is about 2·2.

FIG. 1

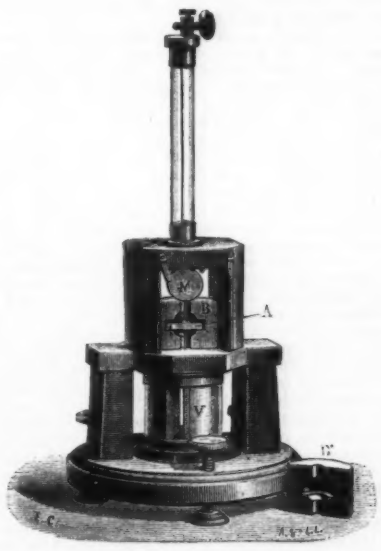


FIG. 2

KOHLRAUSCH'S MAGNETOMETER.

For ordinary uses, a copper deadening device may be added to the instrument, and be placed in the box that contains the magnetized mirror. This box is cylindrical in shape and is closed by a piece of slate and a plate of polished glass. With these two systems of deadening the oscillations the coefficient becomes about 6. The reading of the instruments is effected by means of a telescope placed perpendicularly to the magnetic meridian. If this mode of reading presents any difficulty, a magnetometer may be employed, the mirror of which can be turned in a proper position. Fig. 2 shows such a form of the instrument. M is the mirror, A is the magnetized needle, and V is Toepler's oscillation deadener. As in the other instrument, there is a copper deadener, B B'. Owing to the lightness of the movable parts, these instruments are very sensitive. These two magnetometers form part of a tangent galvanometer. This latter will doubtless remain the apparatus that will be employed by preference for absolute measurements of the intensities of currents. Fig. 3 gives a general view of the apparatus. A turned copper ring, 400 mm. in diameter, 4 mm. in thickness, and 8 mm. in length, is cut, and its two ends are first connected by a piece of ivory. It is provided with two pieces of copper, which are insulated by a sheet of mica, and which lead the current. These two strips of copper are held against each other by two ebonite clamps, and are supported by a screw. In order to obtain the constant of the galvanometer, the calculation is made by supposing, in the first place, the ring entire, and deducing the influence of the two strips of copper by the correction:

$$\frac{(a\,lr + \frac{1}{2}l)}{(r^2 + r + l)^{\frac{3}{2}}},$$

where l designates the length of the strips, and a the distance of the two centers. As shown in Fig. 3, the ring is

FIG. 3

KOHLRAUSCH'S TANGENT GALVANOMETER.

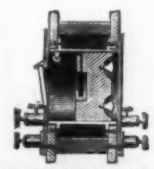


FIG. 6.—KOHLRAUSCH'S GALVANOMETER.

FIG. 4

attached to the support by a rod of dry wood. In order to determine its mean diameter it is measured on several conjugate axes by means of a circle or of a comparing rule. For less important measurements the magnetometer may be replaced by a simple compass having a large index (Fig. 4).

When it concerns the measurement of very feeble currents, Mr. Kohlrausch employs the galvanometer shown in Fig. 5, and in the construction of which he designed to obtain an apparatus of small dimensions, light and easy to mount, and in which the deadening of the oscillations should be variable. To this were added the conditions that the bobbin should not be perforated, that the coefficient of torsion should not be too great, and that the apparatus might be employed within extended limits for measuring feeble currents, and as a differential galvanometer. We believe that Mr. Kohlrausch has succeeded very well in satisfying such conditions. Figs. 5 and 6 give a general view and a section of the instrument. The needle, a magnetized mirror 18 mm. in diameter, is suspended in an elliptical box in order that the cocoon suspension-fiber be not too short. The internal diameters of the ellipse are 30 and 60 mm. The length of the bobbin is 30 mm. The suspension fiber being 20 mm. in length, the coefficient of torsion reaches only 0·001.

FIG. 5.—KOHLRAUSCH'S GALVANOMETER.

The deadening arrangement is made of electrolytic copper, and may be slid into the bobbin as far as to a stop, if a maximum effect is desirable. In such a position the steel mirror is surrounded by the deadening device (as shown in Fig. 6). There is a small groove in the latter for the suspension thread. If it be desired to diminish the deadening of the oscillations, it will be only necessary to move the device back a little. There are two pairs of coils upon the galvanometer, and the degrees of sensitiveness of these are in the proportion of 1 : 10. There are, in the first place, the four degrees of sensitiveness, 1, 2, 10 and 20. The resistances of the coils are 0·5 and 30 ohms. With the fine wire coil, a current of 10^{-7} amperes still gives a visible deflection. A directing magnet, suspended from a small wooden tripod, serves for varying the sensitiveness and the azimuths of observation. If the directing magnet be abandoned, the coefficient of retardation in the oscillations is about 3. But a state of aperiodicity may be reached, after tripling the duration of an oscillation, by employing the directing magnet

FIG. 7.—KOHLRAUSCH'S UNIFILAR ELECTRODYNAMOMETER.

for diminishing the magnetic field in which the magnetized needle is situated.

For alternating currents Mr. Kohlrausch has constructed a unifilar electro-dynamometer. The application of Weber's electro-dynamometers is becoming more and more frequent. If we desire to give a notable sensitiveness to the instrument, we are forced to employ very long suspension wires, since we cannot diminish the distance of the two wires at will without making the direction of the suspended bobbin uncertain. Then the only means of making a transportable electro-dynamometer of great sensitiveness consists in the use of a unifilar suspension. One delicate point is that which relates to the entrance of the current. We might employ a taut wire of considerable length; but that would render the instrument somewhat inconvenient. Yet, if we employed the instrument only for alternating currents, we might employ, as a second entrance, an electrode which dipped into a liquid conductor, and which would serve at the same time to deaden the oscillations. It is in this way that Mr. Kohlrausch has constructed his unifilar electro-dynamometer.

The electrode is surrounded by a second plate in a glass

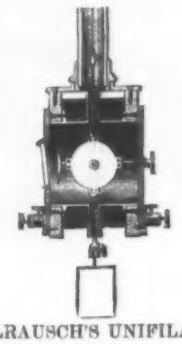


Fig. 8.—KOHLRAUSCH'S UNIFILAR ELECTRO-DYNAMOMETER.

vessel filled with 20 per cent. sulphuric acid. The vessel is suspended by a bayonet catch from a metallic tripod which is in contact with the fixed electrode (Fig. 7). The movable electrode is attached by a platinum wire to another and stronger wire fixed to the movable bobbin. In order to avoid the disturbing influence due to the tenacity of the surface of the liquid, it is necessary that the electrode shall be entirely immersed. The movable bobbin consists of a small ivory frame wound with wire 0·1 mm. in diameter. Fig. 8 shows this bobbin with the reading mirror and the deadening electrode. The suspension wire is of brass and from 0·05 to 0·1 mm. in diameter. It is carried by a glass micrometer tube constructed in the usual way. The frame of the external bobbin is made of wood at the sides, and the brass tube on which the wire is wound is slit in order to prevent induction.

The amount of the total resistance of the two bobbins is about 30 ohms. A current of 0·001 ampere gives a deflection of 300 mm., the distance between the scale and mirror being 2 m. The coefficient of the deadening of the oscillations is 1·5 However, this may be increased by employing electrodes that are larger or that are arranged in the form of a cross.—*La Lumiere Electrique.*

LIPPMANN'S MERCURIAL GALVANOMETER.

The annexed figures, 1 and 2, represent an interesting mercurial galvanometer devised by Mr. Lippmann.

The two polar extremities of a powerful permanent magnet, M, are set into two pieces of soft iron, F. The special form of these pieces is shown in Fig. 2. Their internal and well insulated surfaces are separated by an interval of $\frac{1}{10}$ of a millimeter. This very small interpolar space forms the median part of an open, U-shaped manometer whose two branches rise vertically. The current to be measured is introduced through the terminals, A and B (Fig. 1), which

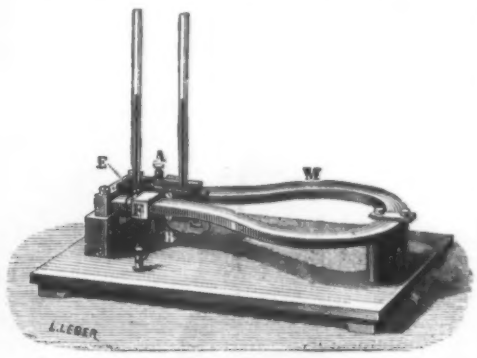


Fig. 1

communicate with two pieces of platinum that touch the surface of the mercury inclosed between the polar pieces. The mercurial chamber is hermetically connected with the two branches of the manometer, and this essential part of the galvanometer is held between two sheets of ebonite that protect the whole.

If a current be passed through the mercury placed between the poles of the magnet, M, the metal will rise in one branch of the manometer and descend in the other, and the difference in the level will be proportional to the current's intensity. The theory of this new apparatus is very simple.

Let us suppose that we pass a current having an intensity, I, through a parallelopiped of mercury placed in a magnetic field; and let us suppose that this mercury inclosed between the poles communicates with the manometric tubes through very small apertures, allowing us to consider the liquid conductor as having strictly the form of a parallelopiped. Under such circumstances the conductor will have a tendency to move perpendicularly to the lines of force and in a definite direction. But, as the conductor is a liquid, the result will be that the mercury will rise in one of the tubes until the pressure resulting from the difference of levels balances the electro-magnetic pressure bearing in an opposite direction.

Now, as despite the movement of the mercury there is no change in the form of the conductor, nor in its position in the magnetic field, the indications will be strictly proportional to I.

But, in order to render the mercurial galvanometer prac-

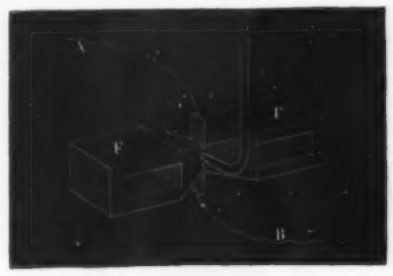


Fig. 2

tical, it is necessary to make it sufficiently sensitive, and it is in the realization of such conditions of a maximum of sensitiveness that we see the essential part—the character of novelty of the instrument. In order to make this galvanometer as sensitive as possible, it is necessary to find by what mode of construction we shall obtain a maximum of hydrostatic pressure, p, for a given current, I. Let A B C D

Fig. 3

Figs. 1, 2, and 3.—LIPPMANN'S MERCURIAL GALVANOMETER.

(Fig. 3) be the parallelopiped of mercury. The current is traversing it in the direction shown by the arrow, and the lines of force are perpendicular to the surface, A B C D. Let l be the height of the parallopiped, and e its thickness in the direction of the lines of force. The force that tends to move the conductor perpendicularly to the lines of force is

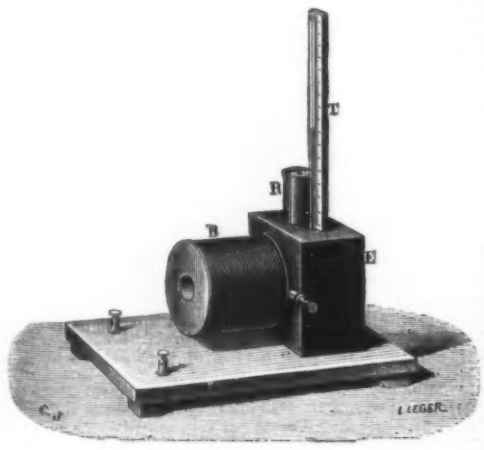


Fig. 4

proportional to the intensity of the current, I, to that of the magnetic field, H, and to the length of the conductor, l. It is therefore proportional to I H l.

This force exerts itself upon the surface of the parallelogram, whose height is l, and whose width is e; and its surface, then, is le. To obtain the pressure, p, per unity of

Fig. 5

Figs. 4 and 5.—LIPPMANN'S MERCURIAL ELECTRODYNAMOMETER.

surface, it is necessary to divide I H l by le. The pressure, then, will be—

$$= \frac{\text{IH}l}{le} = \frac{\text{IH}}{e}$$

This equation at once indicates to us the conditions that must be fulfilled in order to obtain a maximum of pressure: (1) It is necessary to have the magnetic field as intense as possible—which is done by using a strong magnet, and bringing the poles as close together as possible; and (2) e should be as small as possible—which is effected again by the closeness of the poles. This coincidence of two conditions has permitted a galvanometer to be devised that is sufficiently sensitive for practical purposes.

It is evident that this apparatus is aperiodic. The one presented to the French Academy gave a difference of level in the mercury equal to 63 mm. for one ampere.

Figs. 4 and 5 represent an electro-dynamometer based upon the same principle. The magnetic field is formed by the same current, which, before passing through the mercury, traverses a solenoid, B (Fig. 4), in whose center is placed a layer of mercury, LL. One branch of the manometer is replaced by a reservoir, R, for the reason that in the electro-dynamometer the pressure is exerted in but one direction.

The mercury is placed upon an ebonite core that enters as far as to the center of the solenoid, and the current is led by two strips of platinum that communicate with the two opposite sides of the mercury. Two conduits, which are shown by the dotted lines, and which penetrate the ebonite, put the mercury in communication with the tube on one side and with the reservoir on the other.—*La Lumiere Electrique.*

NATIONAL HEALTH AND WORK.*

By Sir James Paget.

It was very difficult to select, from the vast number of subjects relating to health and to education, one of which I could fitly speak to-day. On general education I could not venture to speak; and, believing that I should have to address a large and various audience, I thought it would be best to choose a subject by which I might urge one of the chief objects of this Exhibition, and one which I know that you, sir, have always had in view, namely, that the public themselves should consider, much more than they do, the utility and the means of maintaining their own health. I have, therefore, chosen the relation between the national health and work; especially as it may be shown in a few of the many examples of the quantity of work which is lost to the nation, either through sickness or through deaths occurring before the close of what may fairly be reckoned as the working time of life. I think it may be made clear that this loss is so great, that the consideration of it should add largely to the motives by which all people may be urged to the remedy of whatever unwholesome conditions they may live in. It is a subject which is often in the minds of the real students of the public health, but the public itself is far too little occupied with it.

I shall speak only of national health. In consideration of his own self, a man may be deemed healthy who lives idle, comfortably, and long; who enjoys every day of his life, and satisfies every natural appetite without consequent distress. And when such a one dies of old age, with a timely, uniform, and painless decay of every part, he may be deemed to have been completely healthy. And yet it is possible that he may have enjoyed his own health in the midst of a poor, unhealthy, and unhappy nation, to which he has done no good whatever.

If we could find a nation composed of people such as this man, we might be bound to speak of them as healthy; but we should be right in calling the whole nation utterly unsound, and might safely prophesy its complete stagnation, or its quick decline and fall.

It is not health such as this—idle, selfish, unproductive—that we want to promote either in the individual or in the multitude. Comfortable idleness, such as that of some vagrants and fine gentlemen, is a despicable result of good health; it is what no thorough man would ever wish for. In view of the national health and welfare, the pattern healthy man is one who lives long and vigorously; who in every part of his life, wherever and whatever it may be, does the largest amount of the best work that he can, and, when he dies, leaves healthy offspring. And we may regard that as the healthiest nation which produces, for the longest time, and in proportion to its population, the largest number of such men as this, and which, in proportion to its natural and accumulated resources, can show the largest amount and greatest variety of good work.

Here let me insert, as an interpretation clause, that in all this and what is to follow the word "man" means also "woman," and "he" means also "she;" and that when I speak of work, I mean not only manual or other muscular work, but work of whatever kind that can be regarded as a healthy part of the whole economy of the national life. And I shall take it for granted that a large portion of all national welfare is dependent on the work which the population can constantly be doing; or, if I may so express it, that the greater part of the national wealth is the income from the work which is the outcome of the national health.

It is a common expression that we do not know the value of a thing till we have lost it; and this may be applied to the losses of work which are due to losses of national health. There are very few cases in which these can be estimated with any appearance of accuracy; but I am helped to the best within our present reach by Mr Sutton, the actuary to the Registry of Friendly Societies. In his office are the returns, for many years past, of the sickness and mortality among the members of a very large number of these societies; and, among other things, there is recorded the number of days which each member, when "off work" on account sickness, receives money from his society. Hence Mr. Sutton can estimate, and this he has been so good as to do for me, the average number of days' sickness and consequent loss of work among several hundred thousands of the workmen and others who are members of these societies. From the entire mass of these returns, he deduces that the average number of days' sickness, per member per annum, is very nearly 1¼ weeks; and this agrees, generally, with the estimates made in other societies by Mr. Neison and others. But the averages thus obtained include the cases of members of all ages, and among them many cases of chronic sickness and inability to work during old age. In order, therefore, to get a better idea of the actual annual loss of work through sickness, he has calculated the average annual number of days' sickness of each person during what may be deemed the normal working time of life; that is, between 15 and 65 years of age. This he has done among the members of the large group of friendly societies known as the Manchester Unity of Odd Fellows; and then, on the fair assumption that the rates of sickness of the whole population during the working years of life would not be far different, he has cal-

* Address delivered by Sir James Paget, Bart., F.R.S., at the International Health Exhibition, 17th June, 1884.

culated the following tables, showing the average annual rates of sickness of each person enumerated in the Census of 1881 as living between the ages of 15 and 65.

Ages.	Number of males: Census of 1881 (England and Wales).	Weeks' sickness per annum, according to the experience of the Manchester Unity.	Average sickness per individual per annum (in weeks).
15–20	1,268,269	844,428	0·666
20–25	1,112,354	820,183	0·737
25–45	3,239,432	3,224,134	0·995
45–65	1,755,819	4,803,760	2·736
All ages from 15—65.....	7,375,874	9,692,505	1·314

Ages.	Number of Females: Census of 1881.	Weeks' sickness per annum, according to the experience of the Manchester Unity.	Average sickness per individual per annum (in weeks).
15–20	1,278,963	851,701	0·666
20–25	1,215,872	806,685	0·737
25–45	3,494,782	3,476,146	0·995
45–65	1,951,713	5,368,229	2·751
All ages from 15—65.....	7,941,330	10,592,761	1·334

Briefly, it appears from these tables that the average time of sickness among males during the working year is 1·314 weeks—that is, a small fraction more than nine days in each year—and that among females it is a small fraction more. The result is that among males there is a loss of 9,692,505 weeks' work in every year, and among females a loss of 10,592 761 weeks. Thus we may believe that our whole population between 15 and 65 years old do, in each year, 20,000,000 weeks' work less than they might do if it were not for sickness. The estimate is so large that it must, on first thoughts, seem improbable; but on fair consideration I believe it will not seem so. For the members of the Manchester Unity who are in the working time of life, the reckoning is certainly true, and it is founded on the experience of between 300,000 and 400,000 members. In respect of health they may represent the whole population, at least as well as any group that could be taken. They are not very strictly selected—they are not picked lives; yet they are such as are able, when they are in health, to earn good wages or good salaries, and, as their prudence in joining this association shows, they are comparatively thrifty and careful persons. They do not, at all events, include many of the habitual drunkards, the cripples or utterly invalids, or those who, through natural feebleness or early disease, or mere profligacy, cannot earn enough to become members or maintain themself in membership. Neither do they include many of the insane, or imbecile and idiotic, of whom there are, in our population, nearly 70,000, doing no work, and losing not less than 3½ millions of weeks' work in the year.

It would be tedious to tell the grounds on which the estimate may be deemed too high, for just as many and as good could be told on which it might be deemed too low. And it is rather more than confirmed by some estimates of the annual sickness in other and very different groups of persons.

In the Army, at home, the average number of days' sickness in each year is, for each soldier, about 17; and, as the number of the troops in the United Kingdom is more than 80,000, we have here a loss of about 200,000 weeks' service in each year.

In the Navy, on the home stations, the average number of days' sickness in each year has been in the last five years for each man nearly 16; so that for the total of about 20,000 men there is a loss of 45,000 weeks' services in each year.

The amount of sickness in the services thus appears much higher than in the friendly societies. This is due, in great part, to the fact that a soldier or a sailor is often put off duty a day or two for much less illness than that for which a civilian would "go on his club." Still, the one estimate may confirm the other; for the sickness in the Army and Navy is that of picked men, who were selected for the services as being of sound constitution, and who are in what should be the best working years of life; and if it includes many cases of sickness for only a day or two, it excludes nearly all cases of more than a few months, such as make up a heavy proportion of the average sickness in the friendly societies and in the general population.

And I may add that the estimate from these societies, that nine days in the year may justly be thought a fair estimate of the working time lost by sickness, is confirmed by the records of sickness among the 10,000 members of the metropolitan police force; for among these, including cases of long illness such as are also in the societies, the average is more than nine days in the year.

I think, then, that we cannot escape from the reasons to believe that we lose in England and Wales, every year, in consequence of sickness, 20,000,000 of weeks' work, or, say, as much work as 20,000,000 of healthy people would do in a week.

The number is not easily grasped by the mind. It is equal to about $\frac{1}{19}$ part of the work done in each year by the whole population between 15 and 65 years old. Or, try to think of it in money. Rather more than half of it is lost by those whom the Registrar-General names the domestic, the agricultural, and the industrial classes. These are more than 7,500,000 in number, and they lose about 11,000,000 of weeks; say, for easy reckoning, at £1 a week, and here is a loss of £11,000,000 sterling from what should be the annual wealth of the country. For the other classes, who are estimated as losing the other 9,000,000 week's work, it would be hard and unfair to make a guess in any known coin; for these include our great merchants, our judges and lawyers, and medical men, our statesmen and chief legislators; they include our poets and writers of all kinds, musicians, painters, and philosophers; and our princes, who certainly do more for the wealth and welfare of the country than can be told in money.

Before I speak of any other losses of work or of wealth due to sickness, permit me, as in parenthesis, to point out to you how very imperfectly these losses are told or even suggested by our bills of mortality. These, on which almost alone we have to rely for knowing the national health, these tell the losses of life, and more than misery enough they tell of; but to estimate rightly the misery of sickness, and the losses of all but life that are due to it, we need a far more complete record than these can give.

Take, for example, such a disease as typhoid fever—that which Mr. Huxley has rightly called the scourge and the disgrace of our country. It has of late destroyed, in England and Wales, among persons in the working time of life, nearly 4,000 in the year. Its mortality is about 15 per cent., so that if in any year 4,000 die of it, about 23,000 recover from it. Of these, the average length of illness is, on the authority of Dr. Broadbent, about ten weeks. Here, therefore, from one disease alone, and that preventable, we have an annual loss of 230,000 weeks' work, without reckoning what is lost with those who die. And the same may be said of nearly all the diseases that are most prominent in the bills of mortality. The record of deaths, sad as it is, tells but a small part of the losses of happiness and welfare that are due to sickness. It is as if in a great war we should have a regular return of the numbers killed, but none of the numbers wounded, though these, more than the killed, may determine the issue of the war.

Let me now tell of another loss of work and of money through sickness and early death. In all the estimates I have yet referred to, no account is taken of those who are ill or die before they are 15 years old. They are not reckoned as in the working-time of life, though in some classes many thousands of them are. [In the domestic, agricultural, and industrial classes of the Registrar-General nearly half a million of them are included.] And yet the losses of work due to sickness among children must be very large. Consider the time which might be spent in good productive work, if it were not spent in taking care of them while they are ill. Consider, too, the number of those who, through disease in childhood, are made more susceptible of disease in later life, or are crippled, or in some way permanently damaged; such as those who become deaf in scarlet fever, or deformed in scrofula or rickets, or feeble and constantly invalid, so that they are never fit for more than half work, or for work which is only half well done. These losses cannot be counted, but they must be large; and there are others more nearly within reckoning—the losses, namely, which are due to the deaths of those who die young. If they had lived to work, their earnings would have been more than sufficient to repay it; but they have died, and their cost is gone without return. The mortality of children under 15 in 1882 was nearly a quarter of a million; what have they cost? If you say only £8 a piece, there are more than £2,000,000 sterling thus lost every year. But they have cost much more than this, and much more still is lost by the loss of the work they might have lived to do.

It is, indeed, held, I believe, by some that these things should not be counted as losses; that we have a surplus of population, and that really the deaths of children, though they may be the subjects of a sentimental sorrow, cannot reasonably be regretted. I cannot bring myself to admit that such a thing should ever be argued. I have lived long in the work of a profession which holds that wherever there is human life it must be preserved; made happy, if that can be; but, in any case, if possible, preserved; and no argument of expediency shall ever make me believe that this is wrong. Indeed, I am rather ashamed—even for the purpose I have in view—to use so low an argument as that of expediency in favor of the saving of health and of life. I am ashamed of making money appear as a motive for doing things for which sufficient motives might be found in charity and sympathy, and the happiness of using useful knowledge; but it seems certain that these are not yet enough for all that should be done for the promotion of the national health; therefore, it seems well to add to them any motives that are not dishonorable; and so I add this, that we lose largely not only in happiness but in wealth by the deaths of these poor children.

I will add only one more illustration of these losses, which is always suggested by looking at tables of mortality. The deaths of persons between 25 and 45 years old, that is, during what may be deemed the 20 best working years of life, are annually between 60,000 and 70,000; in 1882 they were 66,000. Think, now, of the work lost by these deaths; and of how much of it might have been saved by better sanitary provisions. If one looks at the causes of their deaths, it is certain that many might have been prevented, or at least deferred. Say that they might have lived an average of two years more; and we should have had in this year and last an increase of work equivalent to that of at least 6,000,000 weeks; as much, in other words, as 6,000,000 people could do in one week.

More instances of losses of work by sickness and premature death might easily be given, but not easily listened to in this huge hall. Let these suffice to show something of our enormous annual loss, not only of personal and domestic happiness—that is past imagining—but of national power and wealth. Surely we ought to strive more against it.

But, some may ask, can these things be prevented? Are they not inevitable consequences of the manner of life in which we choose or are compelled to live? No; certainly they are not. No one who lives among the sick can doubt that a very large proportion of the sickness and the loss of work which he sees might have been prevented; or can doubt that, in every succeeding generation, a larger proportion still may be averted, if only all men will strive that it may be so.

Let me enumerate some of the chief sources of the waste as they appear to one's self in practice.

Of the infectious fevers, small-pox might be rendered nearly harmless by complete and careful vaccination. Typhus and typhoid, scarlet fever and measles, might, with proper guards against infection, be confined within very narrow limits. So, probably, might whooping cough and diphtheria.

Of the special diseases of artisans there are very few of which the causes might not be almost wholly set aside. Of the accidents to which they are especially liable the greater part, by far, are due to carelessness.

Of the diseases due to bad food and mere filth, to intemperance, to immorality, in so far as these are self-induced, they might, by self-control and virtue, be excluded. And with these, scrofula, rickets, scurvy, and all the widespread defects related to them, might be greatly diminished.

It can only be a guess, but I am sure it is not a reckless one, if I say, that of all the losses of work of which I have spoken, of all the millions of weeks sadly spent and sadly wasted, a fourth part might have been saved, and that, henceforth, if people will have it so, a still larger proportion may be saved.

We may become the more sure of what may be done by looking at what has been done already. Let me show some of it; it will be a relief to see something of the brighter side of this picture.

In a remarkable paper lately read before the Statistical Society, Dr. Longstaff says: "One of the most striking facts of the day, from the statistician's point of view, is the remarkably low death-rate that has prevailed in this country during the last eight years." In these years the annual death-rate has been less than in the previous eight years, in the proportion of two deaths to every 1,000 persons living. These average number of deaths has been 50,000 less in the last than in the previous eight years. Doubtless many things have contributed to this grand result, and it is not possible to say how much is due to each of them; but it would be unreasonable to doubt that the chief good influence has been in all the improved means for the care of health which recent years have produced. This is made nearly certain by the fact that the largest gains of life have been in the diminution of the deaths from fever, and of the deaths in children under 15 years old; for these are the very classes on which good sanitary measures would have most influence.

The annual number of deaths from typhus, typhoid, and the unnamed fevers has been about 11,000 less than it was about twenty years ago. The annual number of deaths of children under 5 years old has been about 22,000 less than it was; and that of children between 5 and 15 has been upward of 8,000 less.

These are large results, and though they tell only of deaths, yet they bear on the chief subject I have brought before you—the working power of the nation; for, however much we might assign to improved methods of medical treatment of fever, yet the diminished number of deaths means a very large diminution in the total number of cases. The deaths during the working years of life were 6,500 less; and, this being so, we may hold that, if the average mortality was, say, 25 per cent., the diminution in the total number of cases must have been at least 25,000; and, if we may believe, as before, that each of these involved ten weeks of sickness, we have, in these fevers alone, a clear saving of 185,000 weeks' work in every year.

And so with the diminution of the mortality among children, there must have been a greater diminution in the number of costly and work-wasting illnesses, and a large saving of money that would otherwise have been sunk. And not only so; but many of the children saved in the last eight years will become bread-winners or care-keepers; and who can tell what some of them will become, or what the world would have lost if it had lost all of them?

Let me add only one more reckoning. In a paper last year, at the Statistical Society, Mr. Noel Humphreys showed "that if the English death-rate should continue at the low average of the five years 1876–80, the mean duration of male life in this country would be increased by two years, and that of female life by no less than 3·4 years as compared with the English life-table." And he showed further that "among males 70 per cent., and among females 65 per cent., of this increased life would be lived between the ages of 20 and 60 years, or during the most useful period."

I should like to be able to tell the value in working power of such an addition to our lives. It is equal to an addition of more than 4 per cent. to the annual value of all the industry, mental and material, of the country.

But some will say—admitting that it is desirable, seeing how keen the struggle for maintenance already is, can more than this be done? And the answer may be and must be—much more. In this, as in every case of the kind, every fruit of knowledge brings us within reach of something better. While men are exercising the knowledge they possess, they may be always gaining more. This exhibition has scores of things which are better helps to national health than those of the same kind which we had twenty years ago, and with which the gains already made were won. If I were not in near official relation with the jurors, I would name some of them; there are truly splendid works among them.

But do not let me seem to disparage the past in praising the present. It is difficult to speak with gratitude enough of what has been done, even though we may see, now, ways to the yet better.

Any one who has studied the sources of disease during the last thirty years can tell how and where it has been diminished. There is less from intemperance, less from immorality; we have better, cheaper, and more various food; far more and cheaper clothing; far more and healthier recreations. We have, on the whole, better houses and better drains; better water and air, and better ways of using them. The care and skill with which the sick are treated in hospitals, infirmaries, and even in private houses, are far greater than they were; the improvement and extension of nursing are more than can be described; the care which the rich bestow on the poor, whom they visit in their own homes, is every day saving health and life; and, even more effectual than any of these, is the work done by the medical officers of health, and all the sanitary authorities now active and influential in every part of the kingdom.

Good as all this work has been, we may be sure it may become better. The forces which have impelled it may still be relied on. We need not fear that charity will become cool, or philanthropy inactive, or that the hatred of evil will become indifference. Science will not cease to search for knowledge, or to make it useful when she can; we shall not see less than we do now, and here, of the good results of enterprise and rivalry, and of the sense of duty and the sorrow of shame that there should be evil in the land.

What more, then, it may be asked, is wanted? I answer, that which I have tried to stir—a larger and more practical recognition of the value and happiness of good national health; a wider study and practice of all the methods of promoting it; or at least, a more ready and liberal help to those who are striving to promote it. In one sentence, we want the complete fulfillment of the design of this Exhibition, with all the means toward health and knowledge that are shown in it, and with its handbooks, lectures, conferences, and the verdicts of its juries.

We want more ambition for health. I should like to see a personal ambition for renown in health as keen as is that for bravery, or for beauty, or for success in our athletic games and field sports. I wish there were such an ambition for the most perfect national health as there is for national renown for war, or in art or commerce. And let me end soon by briefly saying what I think such health should be.

I spoke of the pattern healthy man as one who can do his work vigorously wherever and whatever it may be. It is this union of strength with a comparative indifference to the external conditions of life, and a ready self-adjustment to their changes, which is a distinctive characteristic of the best health. He should not be deemed thoroughly healthy who is made better or worse, more or less fit for work, by every change of weather or of food; nor he who, in order

that he may do his work, is bound to exact rules of living. It is good to observe rules, and to some they are absolutely necessary, but it is better to need none but those of moderation, and observing these, to be able and willing to live and work hard in the widest variations of food, air, clothing, and all the other sustenances of life.

And this, which is a sign of the best personal health, is essential to the best national health. For, in a great nation, distributed among its people, there should be powers suited to the greatest possible variety of work. No form or depth of knowledge should be beyond the attainment of some among them; no art should be beyond its reach; it should be excellent in every form of work. And that its various powers may have free exercise and influence in the world, it must have, besides, distributed among its people, abilities to live healthily wherever work must be or can be done.

Herein is the essential bond between health and education; herein is one of the motives for the combination of the two within the purpose of this exhibition; I do not know whether health or knowledge contributes most to the prosperity of a nation; but no nation can prosper which does not equally promote both; they should be deemed twin forces, for either of them without the other has only half the power for good that it should have.

It is said, whether as fact or fable, that the pursuit of science and of all the higher learning followed on the first exercise of the humanity which spared the lives of sick and weakly children; for that these children being allowed to live, though unfit for war and self-maintenance, became thinkers and inventors. But learning is not now dependent on invalids; minds are not the better now for having to work in feeble bodies; each nation needs, for its full international influence, both health and knowledge, and such various and variable health, that there should be few places on earth or water in which some of its people cannot live, and multiply, and be prosperous.

If, therefore, we or any other people are to continue ambitious for the extension of that higher mental power of which we boast, or for the success of the bold spirit of enterprise with which we seek to replenish the earth and subdue it; if we desire that the lessons of Christianity and of true civilization should be spread over the world, we must strive for an abundance of this national health—tough, pliant, and elastic—ready and fit for any good work anywhere.

PASTEUR'S RESEARCHES ON RABIES.

About the middle of December, 1880, Dr. Lannelonque, having been informed that Mr. Pasteur had decided to investigate the subject of rabies, made known to him a case of hydrophobia, which proved the starting point of the illustrious savant's labors in this direction. A child aged five years, whom a mad dog had bitten in the face during the month of November, had been carried to the Trousseau Hospital, where, two days afterward, it died through suffocation from the frothy matter that filled its throat. This mucosity was collected a few hours after death, and, having been mixed with a little water, was used by Mr. Pasteur for inoculating two rabbits with. The animals died two days afterward. Such was the origin of the researches upon rabies, that have been pursued by Mr. Pasteur for four years, and that have rendered him master of this terrible disease. It may be asserted that his patience, his energy, and his precision in the application of his methods were never before put to so delicate a test. It was owing to these qualities, which are so highly developed in him, that he was not obliged to enter a path where he might have met with numerous chances of error. The two rabbits that had been inoculated under the skin of the abdomen did not die of rabies, but any other experimenter less scrupulous and learned than Mr. Pasteur might have supposed that they did, and would have been deceived. But *he* recognized the fact that this doubt was caused by the presence in the inoculating saliva of a microbe foreign to rabid virus. He had discovered a new disease. As for rabies, the problem of its transmission and treatment remained intact.

We pass over in silence his twenty times repeated experiments on the transmission of rabies to animals. The duration of the disease's incubation, whether due to the bite of a mad dog or to inoculation with rabid virus, was long, and Mr. Pasteur was in haste. To wait a month, sometimes longer, for the rabies to make its appearance, so that all of its phases could be observed, did not suit this savant. Humanity likewise was expectant. Learning from the newspapers, or from letters of his students, of the terrible death of people who had been bitten in different parts of the country, he became desirous of hastening as much as possible the hour of his conquest of the most terrible of evils. After a series of experiments, he conceived the idea of inoculating the surface of the brain of a dog with the rabid virus. The animal, with his legs confined to a laboratory bench, and his nose imprisoned in a cylinder containing chloroform, is first trepanned—a very simple operation, and one which, owing to the precautions taken, causes no suffering to the animal. The dog falls asleep under the influence of the chloroform, and offers no resistance to the operator. The animal is prepared as shown in Fig. 1. An incision is made through the skin of his forehead, and he is then trepanned and inoculated by means of a glass syringe and a drop of virus taken from an animal that had died of rabies.

Fig. 1.—DOG PREPARED FOR INOCULATION.

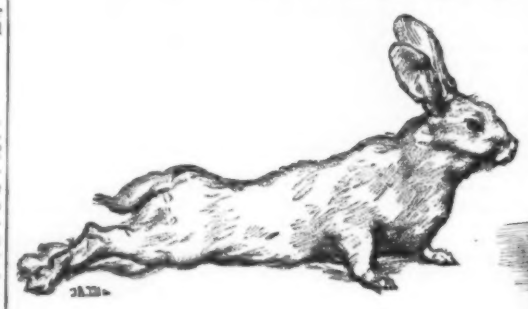


Fig. 3.—AN INOCULATED RABBIT.

Fig. 6.—A DOG WITH RABIES.

After this experiment, Mr. Pasteur found that the period of incubation was lessened. He was no longer compelled to wait a month to study the rabid attack, but only a few days. The first dog thus trepanned ate during the same evening, resumed his appearance of health for a moment, and then became mad. Mr. Pasteur was not only gaining time, but was likewise obtaining proof of what he had suspected, viz., that rabies was a brain disease. He soon found that it also reached the spinal marrow and the entire nervous system; and he concluded therefrom that the virus in the slaver of mad dogs proceeded from nerves that terminated in the salivary glands.

From this moment his experiments gradually extended. The cellar of his laboratory at the Normal School was converted into an apartment for cultivating the rabid virus. Rabbits, monkeys, dogs, and Guinea pigs filled it, and every animal had pasted upon his cage a label upon which Mr. Pasteur wrote with his own hand the dates of the successive inoculations that he had performed upon the occupant. Now note the difference: instead of a hall encumbered with retorts, flasks, and apparatus like those in the first story, where his pupils were engaged in chemical or microscopic studies, this apartment is filled with rabbits—genuine living vessels in which Mr. Pasteur cultivates the virus of rabies just as he cultivates that of charbon and chicken cholera in glass flasks filled with bouillon. It is in this place (Fig. 2) that Mr. Pasteur made his conquest of rabies.

Several times during the day he went down there, and noted in a memorandum book the condition of all his patients. He inoculated the rabbits, like the dogs, on the surface of the brain. These animals are very gentle, and rabies does not affect them as it does the dog. They do not die, but become paralytic in a few days after inoculation. Whenever Mr. Pasteur has any doubts as to the efficacy of the virus, he puts the rabbit on the floor, when, if the virus has not as yet acted, the animal quickly escapes, and it is necessary to run after it and catch it; while, if the contrary is the case, it walks with difficulty. Resting upon its fore paws it has difficulty in crawling forward (as shown in Fig. 3), so complete is the paralysis of the hind parts. After this, death supervenes; the animal's eyes become glassy, it throws its head back, breathes for a few hours in this position, and then expires. After this it is laid upon its cage until the time arrives to carry it to the laboratory to make a study of its organs.

Mr. Pasteur has monkeys likewise that carry the marks of trepanning in their forehead. The virus becomes considerably attenuated in this animal. The one that we repre-

Fig. 2.—MR. PASTEUR IN HIS LABORATORY.

sent (Fig. 4) is very sportive, and, if it is betraying any fear, and if it is clutching the bars at the back of its cage tightly, it is only because it is afraid of our curious face, which is examining it while Mr. Pasteur is explaining to us the operations that he has performed upon it.

Another portion of the cellar is occupied by a kennel. The inoculated dogs are confined in circular iron cages (Fig. 5) provided with strong, closely-set bars. The doors are so arranged as to secure the attendants from harm while introducing food. Mr. Pasteur showed us one of these dogs in a paroxysm of rabies, and remarked to us while doing so, "He will die to-morrow." The animal gazed at him with arched body, drooping tail, and a foaming mouth ready to bite. When Mr. Pasteur struck the base of the cage, the animal gave a single bound in order to seize him. He bit the bars and reddened them with bloody slaver, and then, with blood-stained jaws, and eating the straw of his litter, he walked to the back of his cage. All dogs are not seized with furious rabies, for there are some that die of the paralytic form of the disease. The four types shown in Fig. 7 are in this condition. The end of these is calm, and their keeper may, without danger, caress them when it arrives.

In addition to the dogs that he keeps here, the illustrious savant has a kennel in Rue Vauquelin and another at Montmartre. The animals that he has sacrificed during the course of his researches are to be reckoned by hundreds.

Mr. Pasteur has communicated to the Academy of Sciences the results of his labors on rabies, and which are due to the application of his method of attenuating the viri. As we have said, instead of cultivating these in glass vessels he cultivates them in animals. The same virus attenuated in monkeys becomes a little stronger in rabbits. It may then serve for vaccinating the dog so as to render him proof against rabies. If a dog has been bitten, he will not become rabid if he be inoculated within a week.

Up to the present, Mr. Pasteur has not experimented upon human beings. The results that have been communicated by him to the Academy are to be examined by a committee appointed by the Minister of Public Instruction. There are to be forty dogs experimented upon, twenty of them vaccinated ones. Mr. Pasteur is convinced that those that he has inoculated will not become mad, while the other twenty will all die of rabies.—*L'Illustration.*

FIG. 4.—AN INOCULATED MONKEY

FIG. 5.—CAGE FOR INOCULATED DOGS.

FARMYARD MANURE—A MEDIUM FOR THE DEVELOPMENT OF PARASITIC DISEASES.

By Dr. A. B. GRIFFITHS, F.C.S., Membre de la Societe Chimique de Paris.

THIS memoir intends to detail some recent researches on farmyard manure as a medium for the development of certain parasitic diseases. Although this time honored manure has been looked upon as one of, if not the best, fertilizer known to the cultivator of the soil, yet I wish to show that it may under certain conditions be the means indirectly of destroying his crops instead of feeding them. I took some fresh excrements of the horse, placed them in a dish, and then added a little distilled water, stirred the mixture round with a glass rod, and examined a drop of the liquor under the microscope. I was unable to discover any organisms, but on allowing the dish with its contents to stand forty-eight hours exposed to the air, and then examining, microscopically, I found it full of life—rod-like bodies endowed with the power of active movement; whereas forty-eight hours previously all was quiet in the little drop under the microscope. By this examination I was able to distinguish several forms of *Schizomycetes*, namely, bacteria, bacilli, vibrios, etc. Further than this, these researches show that farmyard manure is a medium in which the *Peronospora infestans* can live to a certain extent, for I have transplanted *Peronospora infestans* from *Solanum tuberosum* (potato) to a quantity of moistened farmyard manure, and kept it in this medium for about two days in a warm place. On examination with the microscope, the mycelia of this parasitic organism had ramified in all directions throughout the little mass of manure. So far I have only been able to see *Peronospora* continue this growth of hyphæ of its life history, and no further. Although I have spent a large amount of time and labor on this most important investigation, I have been unable to witness the production of conidia-bearing branches and gonidia. In fact, the "parasite" in this medium seems only to continue throwing out hyphæ *ad infinitum*. The remaining part (*i. e.*, gamogenesis and the production of oospores) of the life history of *Peronospora*, as far as I am capable of judging, up to the present time, seems impossible in this medium, although, when oospores are transferred from the potato to a fresh piece of moist farmyard manure, they will, on rising the temperature to about 60° C., "germinate," and throw out hyphæ, as already described.

From these investigations, which were conducted with the greatest possible care, it will be seen that *Peronospora* can live to a certain extent in other media besides the potato; but the important bearing of this research is to show that farmyard manure may, under certain conditions and circumstances, become the medium for spreading parasitic diseases among our crops. I have shown that the potato disease will grow to a certain extent in farmyard manure, and if oospores of the *Peronospora* are wafted by winds, and ultimately fall into this medium which nourishes them, they are ready to attack our potato crops when placed in the land containing this farmyard manure, which may already be diseased. Although the agriculturist has a kind of reverence for this manure yet it may be possible that it does more harm than good, and other diseases, common to plants, may thrive well in this medium. It may not be too revolutionary to prophesy that the agriculturist of days to come will turn his back on this time honored "plant food" of his forefathers, and will see the advantages of giving his crops sweeter and better foods to subsist on than this food, which is, according to some chemists, of very little value.

Quoting from a recent investigator, "farmyard manures are *not* sufficient even to restore to the constantly cultivated soils what has been taken out in the crops." Farmyard manure may contain all the ingredients which plants extract from the soil, but it also pleads guilty to containing no less than 95 per cent. of carbohydrates, of which some chemists are of the opinion that there is already a superabundance in the soil. Therefore, if there are 95 cwt. of useless stuff in every 100 cwt. of the manure, what is the use of running the risk of producing diseases in our crops by applying such a poor food to the land? The Chinese, who are the most admirable agriculturists in the world, attach very little value to the excrements of animals as manures; and M. D'Avene (*Biedermann's Centralblatt für Agriculture-chemie*, 1883, 643) has cultivated crops for fourteen years with great success without farmyard manure, employing only artificial manures.

Another argument against the use of farmyard manure is that by its use we are apt to cover our fields and plots of land every year with weeds, for the seeds of weeds are taken up by grazing cattle, and these seeds pass through the alimentary canal undigested along with other waste products; these germinate, and the farmer wonders "where all the weeds come from." It is well known, as Liebig* said years ago, "the fertility of a soil cannot remain unimpaired unless we replace in it *all* those substances of which it has been deprived" by the growth of the crop. This fertility can be entirely kept up by the judicious use of the numerous artificial manures, for, in the words of that celebrated chemist, just quoted, "plants cannot live unless supplied with certain metallic compounds."

These compounds being the bases of our artificial manures, by their use we do not run the risk of adding a substance to the soil which is a medium for the growth and development to a certain extent of parasitic disease, as is the case when we use farmyard manure.

From these investigations it will be seen that the cultivator of the soil has been encouraging disease, if not directly adding it to his land.

I have found that the temperature between 30° and 60° C. is most favorable for the growth of hyphæ of *Peronospora* in farmyard manure. M Déhérain (*Comptes Rendus*, vol. xcviii., No. 6, Feb. 11, 1884) has shown that marsh gas is the product of an organized ferment in farmyard manure, and it may be possible that his organized ferment is one of the fungi.

Referring again to the observation already alluded to, namely, that bacteria and other micro-organisms develop in farmyard manure, I have experimented with various mineral compounds which delay or altogether prevent the development of these organisms. It is important, however, to observe that these low forms of life are themselves much more susceptible to these and similar influences than are the spores or germs which seem to resist almost everything. But I have found that there are certain compounds which destroy completely these bacteria. Examining under the microscope a warm infusion of farmyard manure in which there were numerous bacteria growing and multiplying, I found that running in solutions of the following salts completely destroyed the organisms and the spores: Ferrous sulphate, 0·0269 grm., minimum quantity in 100 grms. of water; cupric sulphate, 0·0073 grm.; and sodium chloride, 5·000 grms., minimum quantities respectively in 100 grms. of water.

As these mineral compounds are all used now as manures, etc., for certain crops, it will be seen that they are useful not only as direct foods for the plant, but are antiseptic agents completely destroying bacteria in farmyard manure, and it is most probable that they will destroy other parasitic forms which are enemies to our crops. I am aware that the investigations of A. Riche (*Journal de Pharmacie et de Chemie*, vol. viii., Nov., 1883) have shown that the vitality of one and the same micro-organism varies extremely according to the medium in which it lives. These growths may be killed by the solutions mentioned when growing in the infusion, yet live when treated with the same antiseptic solutions when growing in other media.

Whether these mineral compounds act in any way on the *Peronospora* and other parasitic fungi which destroy our crops, I am unable to say at present, but intend to thoroughly investigate this important problem.—*Chem. News.*

FIG. 7.—IN THE AGONIES OF DEATH.

* "Organic Chemistry in its Applications to Agriculture and Physiology," page 174.

THE BURROWING CRAY FISH.

IN SCIENTIFIC AMERICAN SUPPLEMENT, No. 446, is an interesting account of the habits of the burrowing cray fishes of the United States. This cray fish is here in numbers away from any streams, but always found in wet or low, marshy ground, and is an intolerable nuisance in both garden and lawn, and for the past two seasons I have been adding coal oil to their water to get rid of them. I am sure that they do not retire to any stream for the winter in this locality; but I think they either hibernate for six months of the year, or are all killed by the winter and a new supply are brought in with the spring rains. I always find the dead ones in spring by hundreds out of reach of any stream on the prairie, and after a hard spring rain any amount of live ones. In spring the dead ones are always larger than those alive. I know that they always work at night; on my lawn and in the garden the top of the mounds show fresh clay in the morning, and I can find them in the grass late in the evening after a shower, but on a clear day they can be found only by digging them out. The chimneys of all I have dug out go down to water. I find that a good supply of coal oil puts a stop to their mound building, and I have used it liberally this summer.

I have seen places on the open prairie, after a fire in spring, that were covered with the shells of dead ones, and no signs of any mounds or any that were alive. But later, after heavy rains, they are to be found everywhere, even in the streets.

ILLINOIS.

Iroquois Co.

PLAGUE OF LOCUSTS IN YUCATAN.

BEING in Yucatan four years ago, we learned that in Tabasco and Chiapas there was an epidemic of cholera, induced by locusts that, a year before, had appeared in great numbers. Millions fell into the water and, rotting there, poisoned it. When the news reached Yucatan the people were terrified, for the elder inhabitants had many a painful recollection of cholera, when the dead were carted through the streets of Merida at all hours of the day and night, and the friend with whom they spoke at midday was, at sunset, thrown into the common pit.

The cholera, however, did not reach Yucatan, but the locusts did, and have so thrived there that they seem quite unwilling to change quarters. When they first flooded the atmosphere, in 1881, and settled at dusk, according to their custom, on every leaf and twig, bearing down widespreading branches, the people said that they ate nothing and did no harm. Boys caught them and amused themselves by maiming them; and grown people, full of superstition, discovered that they wore the so venerated cowl, and had the image of a chalice on the thorax; others found the number 1881 under each wing, and said they were sent by God because the year was marked on them. In some villages their arrival was celebrated by fire works, bell ringing, and music, because the simple inhabitants thought they must receive them with honor. But later on, when they had proved by no means inoffensive, the Bishop, assisted by his clergy, exorcised the legions of locusts. To the astonishment of many, not *even that* was effective. This solemn ceremony took place at the door of the cathedral on the day that they celebrate a festival in honor of St. John the Baptist, in consequence of his having delivered the country from swarms of locusts in the year 1831, according to Father Cogolludo, who in his "History of Yucatan" says: "Seeing that human efforts could not get rid of the locusts, the image of the glorious St. John the Baptist was brought to the holy cathedral, in order to make a rogation. Carried out as intended, our Lord God saw fit that the locust should rise from the earth in such quantities, that where they passed, like a thick cloud, they covered the light of the sun, and nearly all of them went to the sea, and were drowned, the surf afterward throwing great piles of them on to the sea shore. For this divine mercy, the *Cabildo*, on the 30th of July, 1831, made a sworn decree, and vow, to have the saint as patron against that plague."—Lib. x., cap. xvii.

Each female locust multiplies by eighty, and replenishes the land of Yucatan with their species month after month, so that large tracts are covered with a moving mass yet unable to take flight, while overhead their elders stream through the air like a rapidly flowing river.

In the month of November, 1883, while living among the crumbling palaces of Chichen Itza, a procession of locusts, perhaps a mile in width, passed by one spot for seven consecutive days. At dusk all settle, devour what they can find, and rest till nine or ten o'clock the next morning. Their favorite food is tender maize and the leaf of the cocoanut palm, but they also make short work of fruit trees, eating fruit and leaves, at times completely stripping the bark from the trunk and branches. Twenty or more cling to a stout blade of Guinea grass, four or five feet high, and in a few minutes only the stem remains. There are two or three different kinds of locusts. The largest, happily not very numerous, measures about eight inches from the tip of one wing to the other, and is very pretty, having crimson wings, and transparent shields for them. Others are quite yellow, and some yet smaller nearly black. But all are provided with saws on their hind legs, very useful, no doubt, as they enable them to carve their supper off the trees and other plants—if they would but stop there, but no, they destroy more than they eat. Even the *Agave sisalensis*, that yields the Sisal hemp, or henequin, is not always despised by these voracious creatures, and if they succeed in destroying that many a wealthy planter will be reduced to poverty. A constant lookout has to be kept over the fields, so that when locusts approach they may be invited to pass on. They are not hard to persuade. An old tin pan, struck loudly, will frighten them away, and if a few take the lead the rest all follow. It is the same with the "jumpers," as they call those yet unable to fly. One morning, when we came to the foot of the grand old castle of Chichen, a strange rustling sound filled the atmosphere around us, and the cause soon appeared. The large open space, covered with long grass, in front of the castle was teemingwith life; billions of "jumpers," half an inch long, were there, three and four deep, hopping over each other, and all incessantly trying to be uppermost; eggs deposited there had come to life—these eggs can remain under water for a month without being injured in any way, and when warmth reaches them the larvæ spring to life. Our every footstep crushed to death struggling masses; and this patch of jumpers covered an area of half a mile square, which we set on fire to destroy as many as possible. When we approached the edifice where we intended to work, the beautifully sculptured walls and pillars were hidden, thickly covered, but the moment we touched one or two and made them move all followed, and in a few minutes left the spot clear.

When the people saw their crops of maize consumed, they began to clamor to the Government to devise some means of destroying the locusts—a task that armies have failed to accomplish. After much consultation and many disagreements, it was decided that each citizen should sally forth once a week to kill with his own hand a bushel of locusts; and one Saturday afternoon Dr. Le Plongeon was not a little surprised to receive an order from a Meztizo who called at the street door, to be at the city hall at 6 o'clock next morning, to go out in the country and kill locusts. Informed that the order was from the magistrate, Dr. Le Plongeon sent him word that he would be very happy to receive him at home, and they would then go together to kill locusts

Finding that they were unable to compel gentlemen to go out in the fields to thrash and burn their enemy—for those were the means employed—the authorities modified the edict by exacting a fine of fifty cents from such as were unwilling to do the work. The owners of some haciendas paid so much a bushel for dead locusts, to incite their laborers to kill them, and hundreds of thousands of bushels were killed, the papers publishing how many each day, but all to no purpose, it was almost labor in vain. Large trenches were dug in the earth, the locusts driven into them and buried alive, but as it is their custom to bury their eggs, it mattered little to the unborn, and for one that perished there, several by and by came to the surface.

While unable to fly they are not so hard to destroy, but once full grown it is no easy matter. It is astonishing how they resist fire, crawling among burning sticks and seeking to escape, until they drop roasted. When flying, the great number of wings makes a strange noise, like the roaring of the ocean from afar, or a strong wind at a certain distance; and when the sun shines on their transparent wings they look, fluttering in the air, like golden snow, but sometimes they are so numerous as to obscure the light of the sun. The wind, and weariness, sometimes causes them to fly low, but generally they keep a good distance above the lofty cocoanut palms. When their hour comes, they let themselves drop wherever they happen to be, often maiming themselves, and always so extremely exhausted that they are seldom able to escape the boys and dogs that, in inhabited places, delight in catching and torturing them. Happily the birds find them very palatable, especially the jackdaws, which are numerous, and thus they help to destroy them. Every locust has on its mouth a drop of red liquid that changes the color of water as if blood were mixed with it. So far the water in Yucatan has not been spoiled, for the moment the locusts are seen approaching, the people in every house take care to cover their well, and keep it covered while they are passing or hovering over the place, generally three or four hours. Individually they are like the wild bees of Yucatan, in one respect, being harmless, but very annoying. The bees smother themselves in our hair, and crawl into our eyes, nose, mouth, and ears. The locusts enter the houses, saw clothing if they get a chance, wander about the furniture, jump into our face, crawl over books, get up our sleeves, and look for a corner in our hammock. But these are trifles; imagine having the roof eaten from over one's head! Many an Indian family goes to sleep with a neatly thatched roof above them, and in the early dawn open their eyes to see naught between them and the paling stars; the locusts eat the roof while the inmates slumber unsuspectingly.

The question is, What will become of Yucatan? The locusts decline to be exterminated, and seem unwilling to move on. It is useless to plant corn and other things, for they will never let them ripen. It they find nothing but henequin, they destroy and eat the young plants. It is the sale of henequin that enables the people of Yucatan to import thousands of bushels of corn from Mexico and the United States every month; that failing, what can they do? A tornado from the south that would blow the plague into the sea would be a godsend, even if it brought down a few houses. But in the absence of that, why not try to starve them out by planting nothing but palma christi, which they never touch though it is very abundant there, and henequin? They are rather dainty creatures, and might prefer to leave the country in search of better fare than to be condemned to subsist on henequin. At any rate, the plan could be tried, for since crops cannot be raised, why plant?

ALICE D. LE PLONGEON.

PREHISTORIC MAN IN EGYPT AND SYRIA.

A GALA meeting was recently held by the Victoria Philosophical Institute of London, at which its members gave a worthy welcome to Vice-Chancellor Dawson, C.M.G., of McGill University, Montreal, at whose instance the British Association visits Canada this year. The Society of Arts kindly lent its premises for the occasion, and its great theater was crowded in every part long before the hour of meeting. The chair was taken by Sir H. Barkly, G.C.M.G., K.C.B., F.R.S., who—after the new members had been announced by Captain F. Petrie, the secretary—welcomed Dr. Dawson amid loud applause, and asked him to deliver his address. It was on "Prehistoric Man in Egypt and Syria," and was illustrated by large diagrams, also flint implements and bones collected by Dr. Dawson himself on the spot during his winter tour in the East. Professor Boyd-Dawkins, F.R.S., kindly assisted in the classification of the bones. In dealing with his subject Dr. Dawson remarked that great interest attaches to any remains which, in countries historically so old, may indicate the residence of man before the dawn of history. In Egypt, nodules of flint are very abundant in the Eocene limestones, and, where these have been wasted away, remain on the surface. In many places there is good evidence that the flint thus to be found everywhere has been, and still is, used for the manufacture of flakes, knives, and other implements. These, as is well known, were used for many purposes by the ancient Egyptians, and in modern times gun flints and strike-lights still continue to be made. The *debris* of worked flints found on the surface is thus of little value as an indication of any flint-folk preceding the old Egyptians. It would be otherwise if flint implements could be found in the older gravels of the country. Some of these are of Pleistocene age, and belong to a period of partial submergence of the Nile Valley. Flint implements had been alleged to be found in these gravels, but there seemed to be no good evidence to prove that they are other than the chips broken by mechanical violence in the removal of the gravel by torrential action. In the Lebanon, numerous caverns exist. These were divided into two classes, with reference to their origin; some being water caves or tunnels of subterranean rivers, others sea-caves, excavated by the waves when the country was at a lower level than at present. Both kinds have been occupied by man, and some of them undoubtedly at a time anterior to the Phœnician occupation of the country, and even at a time when the animal inhabitants and geographical features of the region were different from those of the present day. They were thus of various ages, ranging from the post-Glacial or Antediluvian period to the time of the Phœnician occupation. Dr. Dawson then remarked that many geologists in these days had an aversion to using the word "Antediluvian," on account of the nature of the work which, in years now gone by, unlearned people had attributed to the Flood described in Scripture, but as the aversion to the use of that word was, he thought, not called for in these days, he hoped it would pass away. Speaking as a geologist, from a purely geological point of view, and from a thorough examination of the country around, there was no doubt but what there was conclusive evidence that between the time of the first occupation of these caves by men—and they were men of a splendid physique—and the appearance of the early Phœnician inhabitants of the land, there had been a vast submergence of land, and a great catastrophe, aye a stupendous one, in which even the Mediterranean had been altered from a small sea to its present size. In illustration of this the caverns at the Pass of Nahr-el-Kelb and at Ant Elias were described in some detail, and also, in connection with these, the occurrence of flint implements on the surface of modern sandstones at the cape or Ras near Beyrout; these last were probably of much less antiquity than those of the more ancient caverns.

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